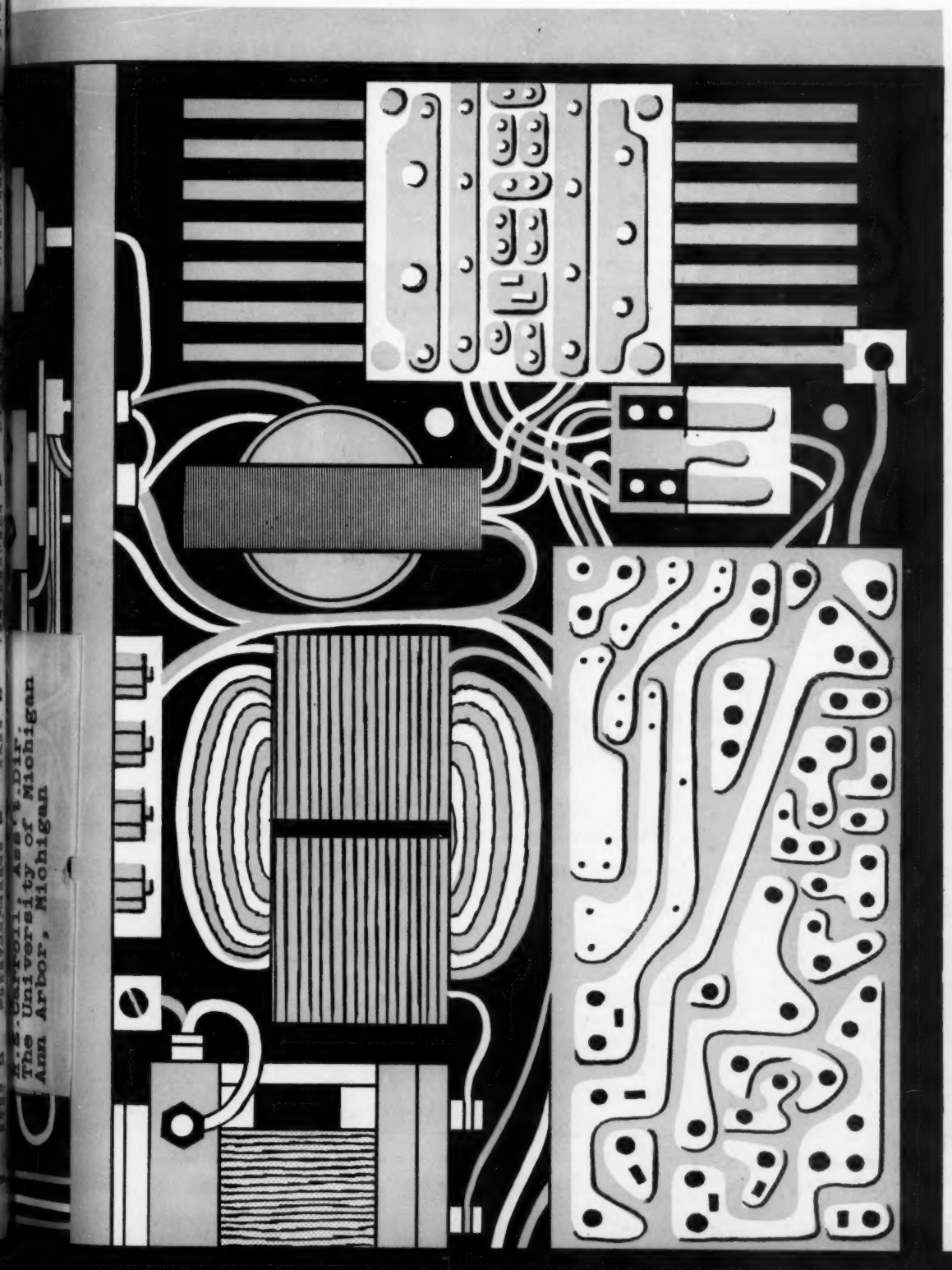
ELECTROMECHANICAL

components & systems | DESIGN

JULY 1960



in this issue components digest 16 DC regulated power supplies

James Flora

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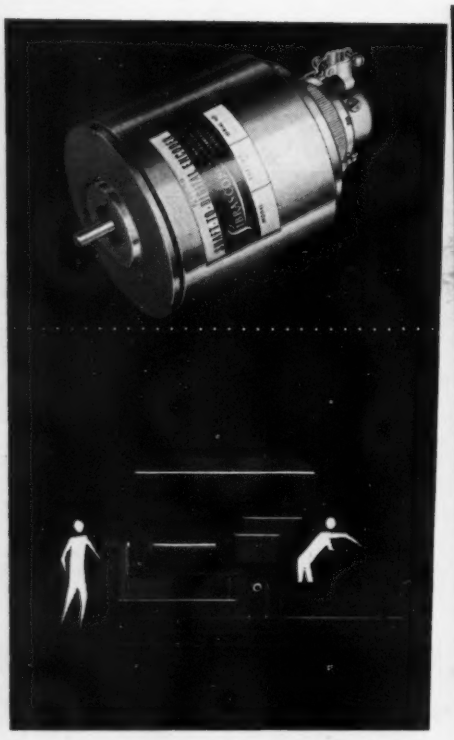

CODE OUTPUT	MODEL NO.	TOTAL CAPACITY	RESOLUTION PER TURN
SERIAL BINARY (LINEAR)	707	7 bits (128)	128
	713	13 bits (8192)	128
	717	17 bits (131,072)	128
	719	19 bits (524,288)	128
BINARY (SIN-COS)	757*	7 bits per quadrant	512
	758*	8 bits per quadrant	1024
BINARY CODED DECIMAL	723 through 735	2,000 through 360,000	200
GRAY	708	8 bits (256)	256
BINARY	740	10 bits (1024)	1024

*Available in hermetically sealed servo-driven package as Models 757-S and 758-S.

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CIRCLE NO. 1 ON INQUIRY CARD

ELECTROMECHANICAL components & systems DESIGN

A Sourcebook of Design Ideas in Applied Electromechanics

JULY 1960 • VOL. 4 NO. 7

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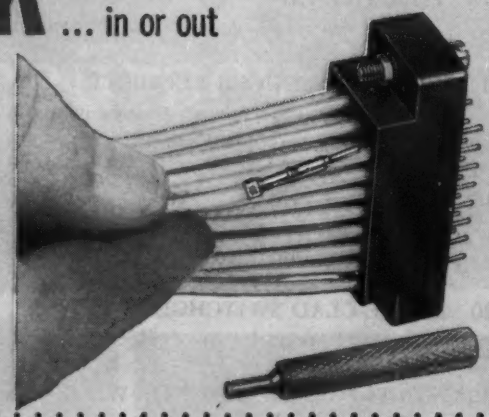

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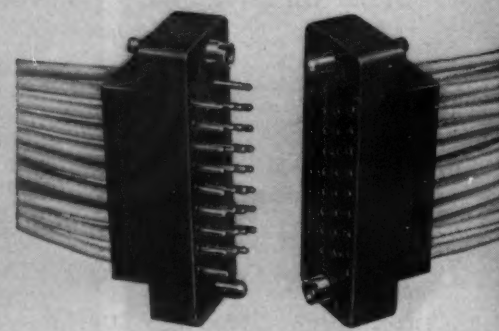

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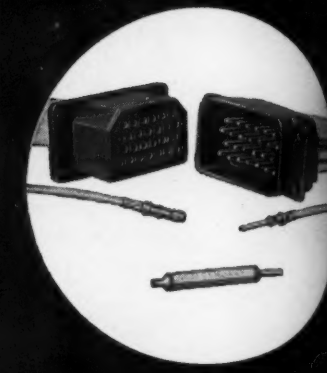

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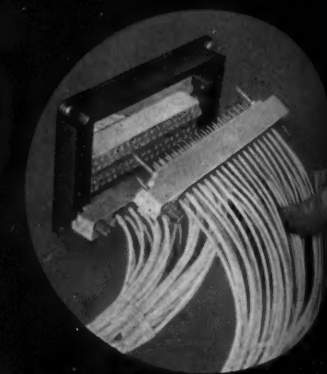

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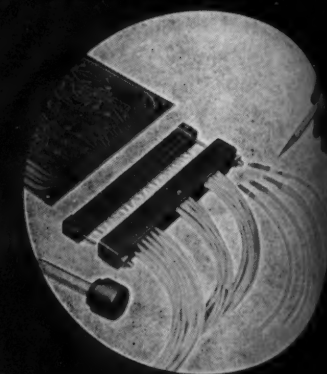

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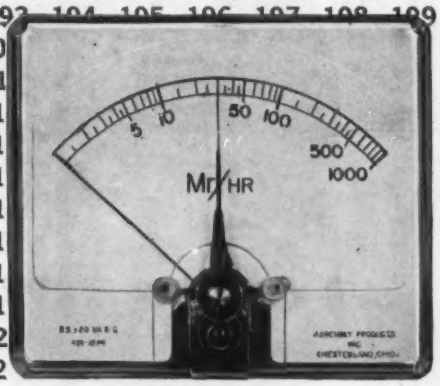

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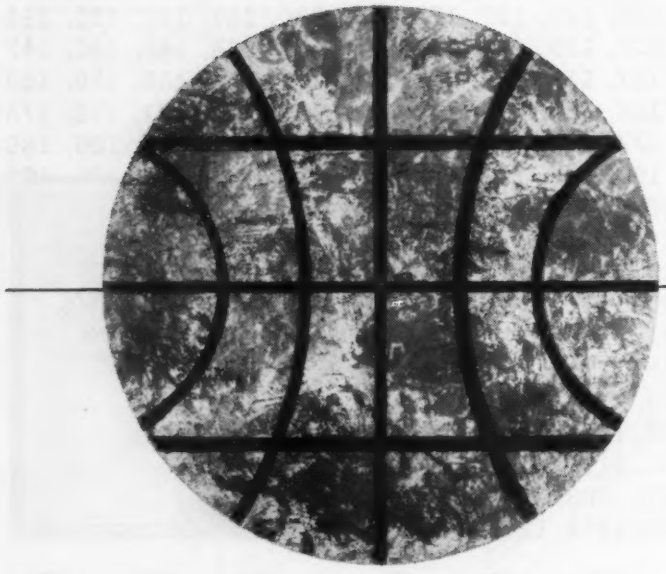

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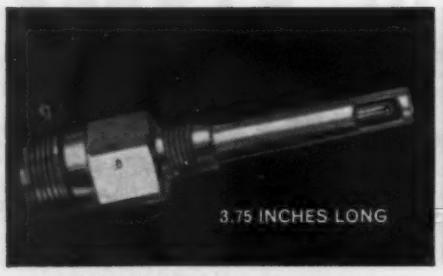

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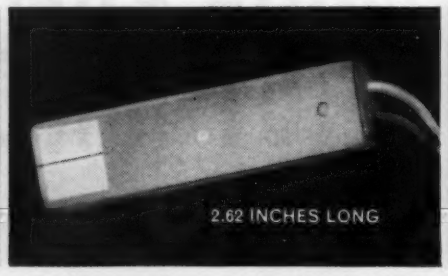

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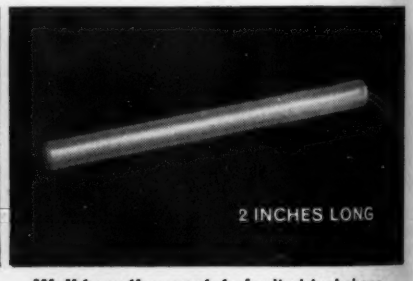

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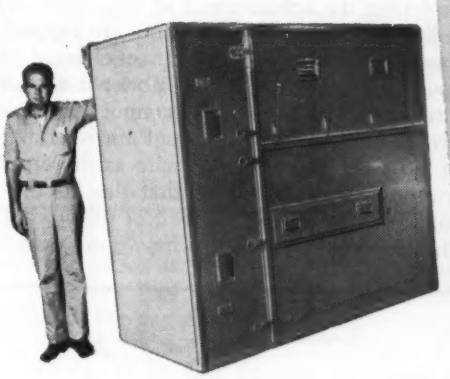

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FILM POT TAP

"Zero" Tap Width Generates Continuous Functions

Can the width of a carbon film potentiometer tap occupy zero space and thus cause no discontinuity in a function? Engineers familiar with wire-wound pots and the manner in which they are tapped may be puzzled by such a claim. Computer Instruments Corp. of Hempstead, L.I., N.Y. claims to have tapped their film pots such, that under certain conditions the width of their taps is practically zero. Before exploring the achievement of this effect, let us comment briefly on how wire-wound pots are tapped.

In wire-wound pots, the resistance element consists of closely spaced fine wire windings about a core, transverse to wiper travel; a tap is made by connecting a contact to a single turn or perhaps two adjacent turns of wire. When the wiper is on the same turn of wire as the tap, the resistance between wiper and tap is that due to the resistance of the length of wire from the point of wiper contact to the point of tap contact. In typical wire-wound pots this length is the equivalent of approximately one-half turn of wire. In a typical pot having 2,000 turns, the minimum resistance between wiper and tap would be 1/4000 of terminal resistance; the minimum voltage would also be 1/4000 of the excitation voltage. The width of tap would be the equivalent of one or two wires; in this same 2,000 winding pot, the width of tap would be approximately 1/3 of a degree.

HOW CARBON FILM POTENTIOMETERS WORK

The resistance element of CIC's film potentiometers as explained by H. H. Adise can be thought equivalent to a single length of fine resistance wire, not wound transversely to wiper motion, but stretched out in a single strand along the direction of wiper motion. Then consider the round wire pressed flat so that it becomes a thin foil of substantially rectangular cross-section, having a width several hun-

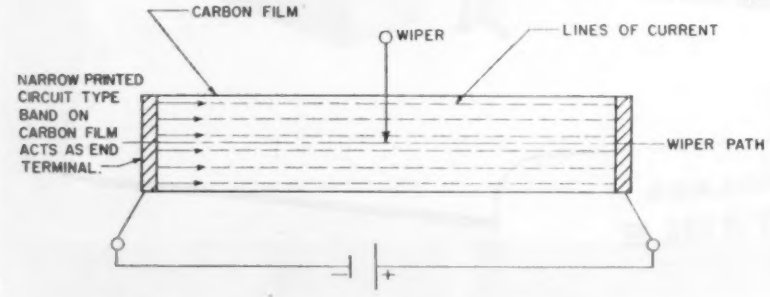


Fig. 1 Voltage distribution between the two end terminals can be represented by an infinite number of lines of equal voltage parallel to the end terminals and perpendicular to the lines of current flux; these are called equipotential lines. Wiper moves along the length of resistance element, thus showing a continuously varying voltage, whether moving along path A, B, or C. (See Fig. 2).

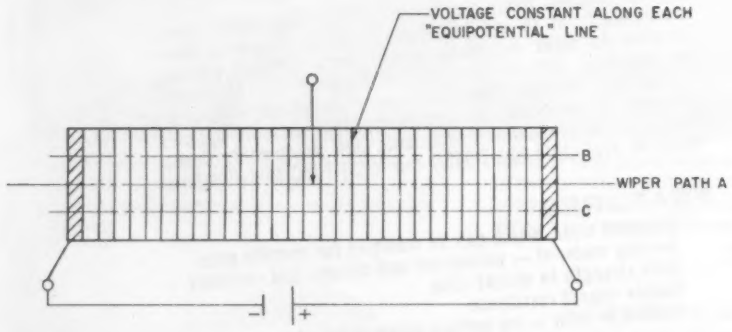


Fig. 2 Assume for the moment that wipers 1 and 2 are moving independently along the resistance element on paths A and B (as in Fig. 3). When both wipers are opposite each other, thus effectively on the same line of voltage, the voltage between them is zero; the *resistance* between is not zero even though the *voltage* is, due to the fact that they are widely separated and the resistivity of the film exists both transversely and longitudinally. The slightest movement of wiper 1 relative to 2 results in a voltage difference between them because 1 will then be on a different equipotential line. As a practical matter, due to the granularity of the film, a wiper motion of approximately five millionths of an inch is necessary to produce a voltage change; in wire-wound pots the equivalent resolution at best is 700 millionths and may be as great as 3,000 millionths.

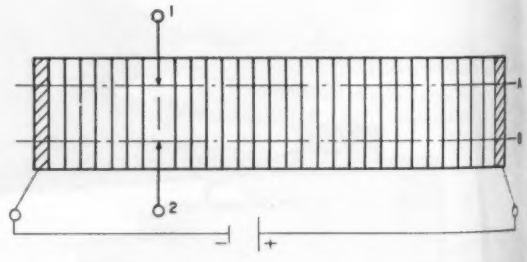


Fig. 3 Assume now that wiper 2 is replaced by an extremely narrow printed circuit type of fixed connection called a tap (See Fig. 4). If voltage between tap 2 and wiper 1 is measured as 1 moves toward 2, the voltage will be seen to drop until at position 1′, the voltage difference will be zero. The wiper is now said to be at the tap position, even though the resistance between them may be quite large; as the wiper moves on past 2, the voltage between wiper and tap will again increase. This movement of the wiper across the tap results in a single point of zero voltage between them. This effect will be observed whether the wiper path is A or B. Such a tap is said to have practically zero width, but finite series resistance.

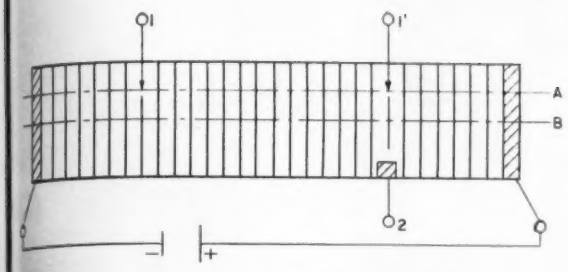


Fig. 4 In practice such a tap has a mechanical width of about 1/64" and extends transversely onto the film about the same amount. It would appear then that a great many equipotential lines are shorted; shorting, however, does not occur due to the field nature of the resistance element in the area of the tap. While in the immediate vicinity of the tap, the lines of equipotential are distorted; some distance away, along the wiper path they are not distorted and the tap thus effectively represents a single line of potential. Net effect is a tap of practically zero width.

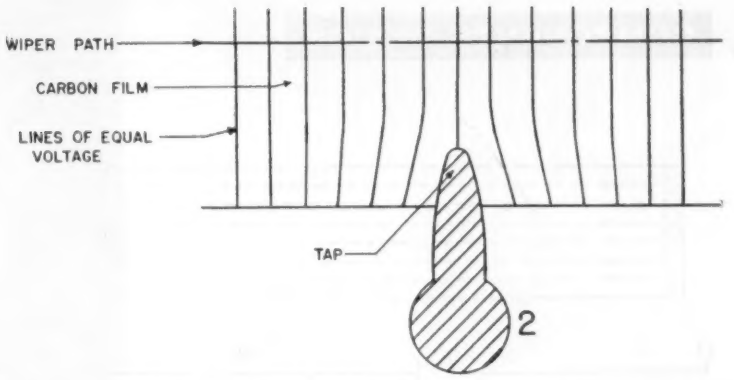
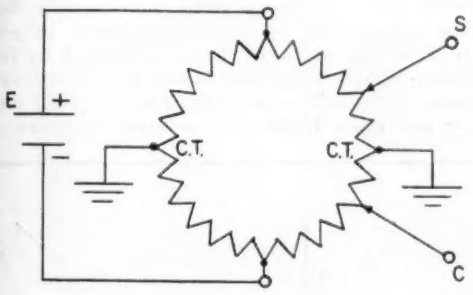


Fig. 5 Such a tap is used where a point of voltage reference is required; a center tap is used where the wiper output voltage is required to increase positively for one direction of wiper motion from the center tap and negatively for the opposite direction. In a sine-cosine pot, for example, the actual circuit schematic looks like Fig. 6.



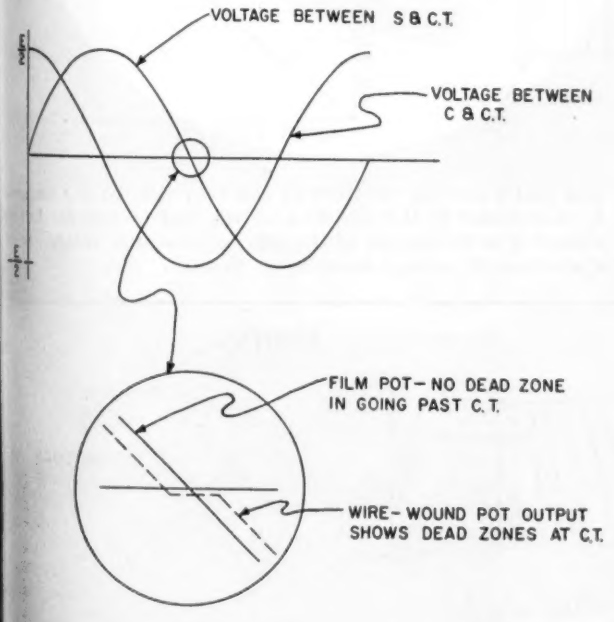

VOLTAGE BETWEEN S & C.T.
VOLTAGE BETWEEN C & C.T.
E/2
E/2
FILM POT—NO DEAD ZONE IN GOING PAST C.T.
WIRE-WOUND POT OUTPUT SHOWS DEAD ZONES AT C.T.

Fig. 6 Comparing the film pot in the above application to wire-wound pots, a wiper motion of five millionths of an inch from the tap position produces a voltage change of proper polarity whereas in a wire-wound pot a motion of as great as 6,000 millionths may be required; the dead band in the wire-wound pots is thus more than 1,000 times greater than in film types.

dred times as great as its thickness. In CIC's pots, high-resistivity carbon replaces the metal wire so that the single strand length has the resistance equivalent to much longer, transversely wound length.

When a voltage is applied between the ends of a fine round wire resistance element, whether single strand or transversely wound, all the current is confined within the diameter of the wire, and flows along its length, following the direction of winding; the width of wiper contact is a substantial proportion of the width of the resistance element, that is, the diameter of the wire. In the case of the film element, the current distributes itself through the entire width of the foil in the nature of a thin band; the wiper width is a small fraction of the total element width.

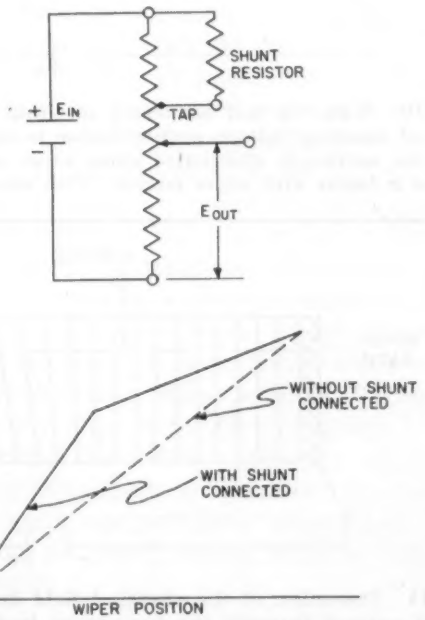


Fig. 7 Taps are used not only for voltage reference points but also for points of excitation or current drain, as for example, where the resistance element is shunted to produce a non-linear output. The schematic above shows the circuit for such a potentiometer.

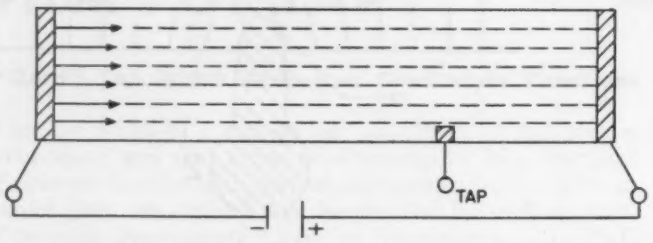


Fig. 8 In the film pot of Fig. 7, the current distribution without shunt is illustrated above.

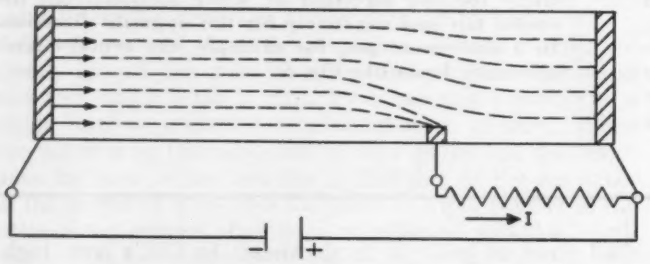
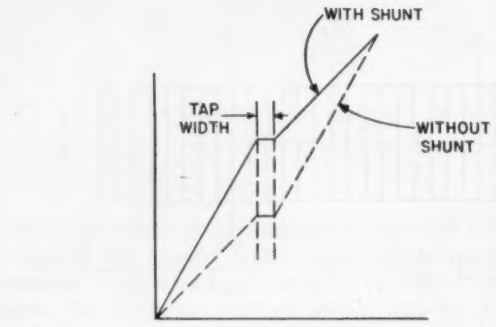


Fig. 9 When the shunt is connected, the current in the left hand portion of the pot is divided in the right hand portion between the resistance element and the shunting resistor, as shown above.



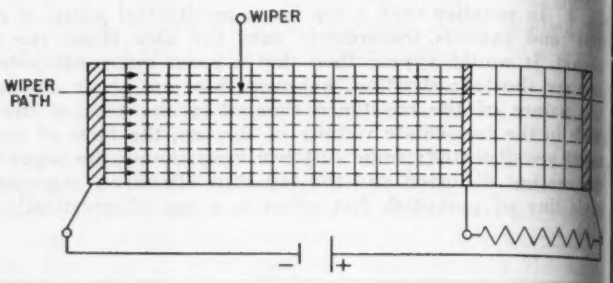
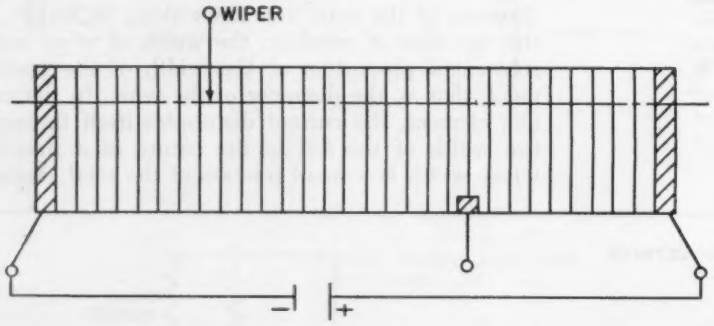


Fig. 12 With shunt disconnected, i.e., tap unused, the finite width tap produces a local non-linearity due to its shortening action. The total linearity error in percent so caused is $\pm\frac{1}{2}$ tap width in degrees, divided by functional angle, multiplied by 100. Thus a one degree tap width with a 300 degree functional angle results in a $\pm.15\%$ error, over and above any other inherent non-linearity errors.



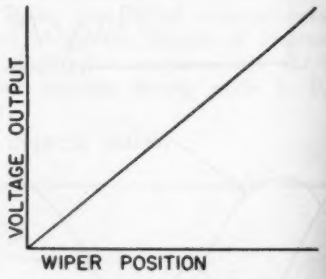
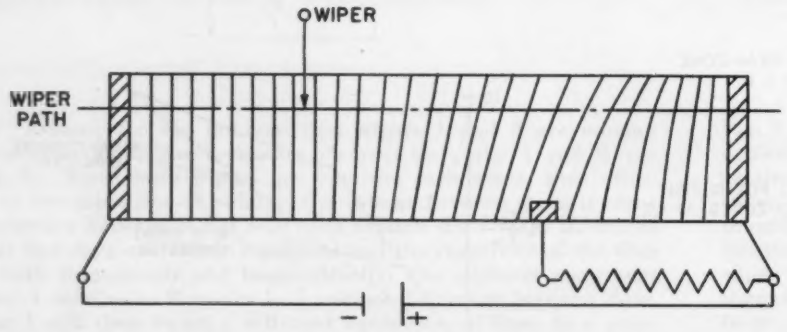


Fig. 10 With tap not connected to shunt of Fig. 7, the lines of constant voltage perpendicular to the lines of current, are uniformly distributed along wiper path so that the output is linear with wiper motion. With shunt between tap and end terminal, the lines of constant voltage are uniformly distributed in the region near the end terminals, but are distorted in the region of the tap, in a manner related to the distortion of current lines, as in Fig. 11.



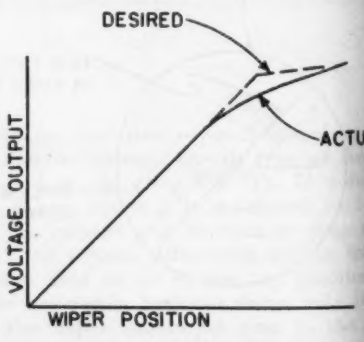
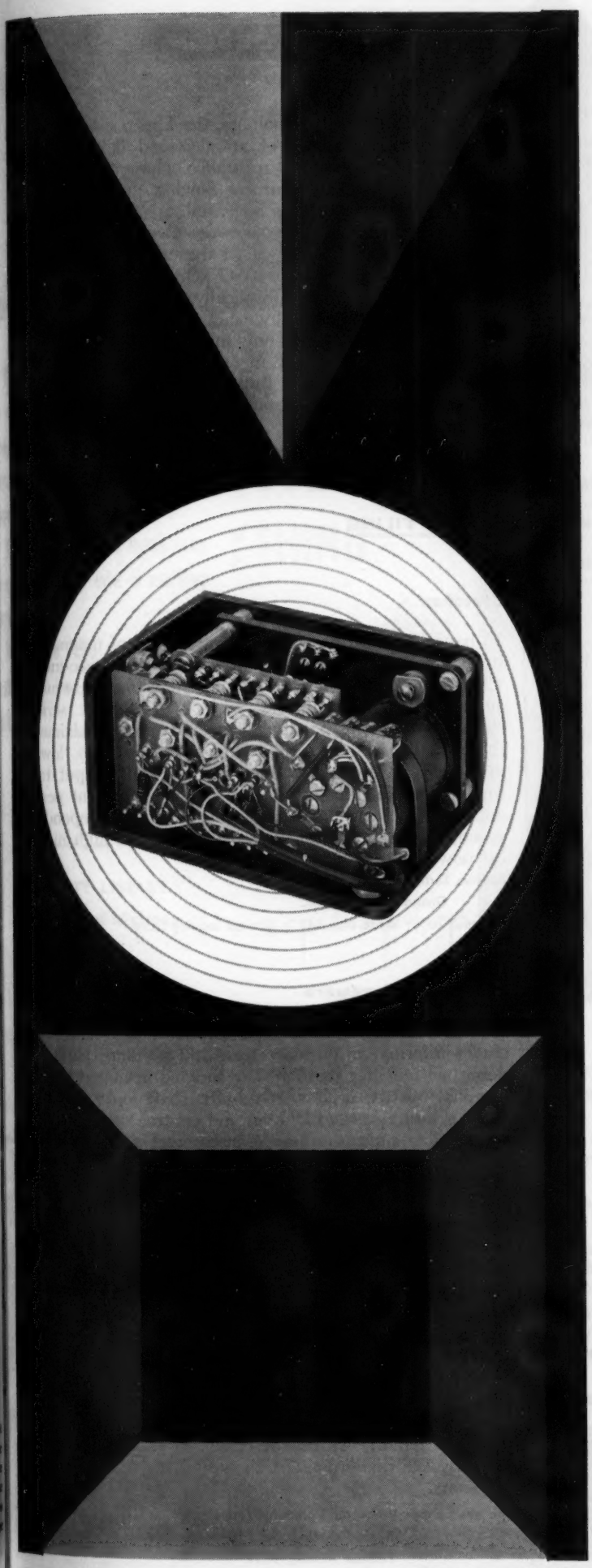


Fig. 11 Distortion of the electrical field due to the drawing of current through the tap causes local non-linearity extending in both directions from the tap. This non-linearity may not be desirable. In this event, a tap of different configuration is used. When large currents are drawn through a tap, the minimum local non-linearity occurs when an extremely narrow tap is drawn completely across the resistance element. There is no local distortion of current lines about the tap, but the tap does act as a dead short; when the wiper traverses the tap, the voltage output will be constant. The resistance between wiper and tap when wiper is on tap is practically zero. Such a tap (see Fig. 12) is called a zero resistance, finite-width tap; this, as opposed to the one described earlier, zero-width, finite-resistance type.



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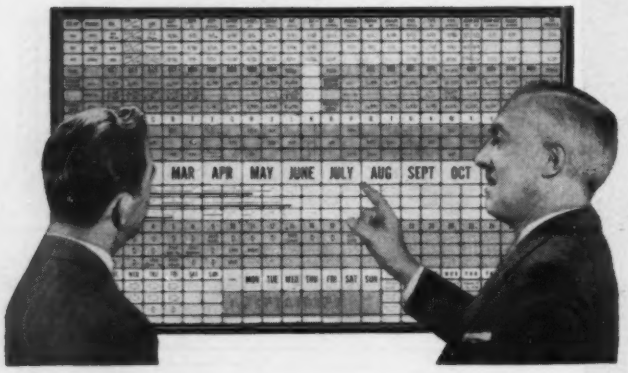

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COMPONENTS DESIGN

When excited with a voltage, the film resistance element takes on characteristics of an electrical field rather than simple lumped-constant resistance characteristics of the wire-wound element. Current flowing through a film resistance element can thus be visualized as an infinite number of parallel lines of flux between the end terminals, with the wiper moving along one of these lines.

Figures 1-12 show how CIC achieved the condition, as illustrated in Fig. 1, of practically zero tap width with no discontinuity in function by using the tap as a voltage reference point or by drawing only infinitesimal currents through it. When the tap acts as an excitation point and relatively large currents are drawn through it, CIC's design provides a tap of finite, though small width with practically zero series resistance.

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WORTH FILING

Clutches

16 page brochure describes characteristics of magnetic particle clutches ranging in capacity from 2.5 ounce-inches to 1,900 pound-inches. Curves and other data are used to acquaint design engineers with 10 different series of clutches and their possible uses. Advantages claimed for the clutches include high torque-to-inertia ratio, low residual torque, low excitation power for full output torque, smooth chatter-free torque transmission, constant performance under environmental extremes, torque independent of speed, torque proportional to excitation and high mechanical power gain.

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Electronic Hardware

32 page catalog of electronic terminals and hardware includes information on more than 380 standard parts. Items described include: standard and molded insulated terminals, terminal boards, eyelets, stand-offs, shaft locks and miscellaneous hardware and handles and control knobs. Cataloged for the first time is a line of instrument control knobs designed to MS-91528 specifications for military applications.

Source: Lerco Electronics, Inc.
Burbank, Calif.

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Toroidal Inductors

Comprehensive wall chart on toroidal and variable inductors contains a dozen pages of catalog information. Includes twenty graphs of Q versus frequency curves for several ranges of voltages or inductance. More than half of these curves are not available from other sources, according to the company. Tables describe electrical characteristics and physical dimensions of 25 typical toroidal and variable inductors.

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Burnell & Co., Inc., 10 Pelham Pkwy.,
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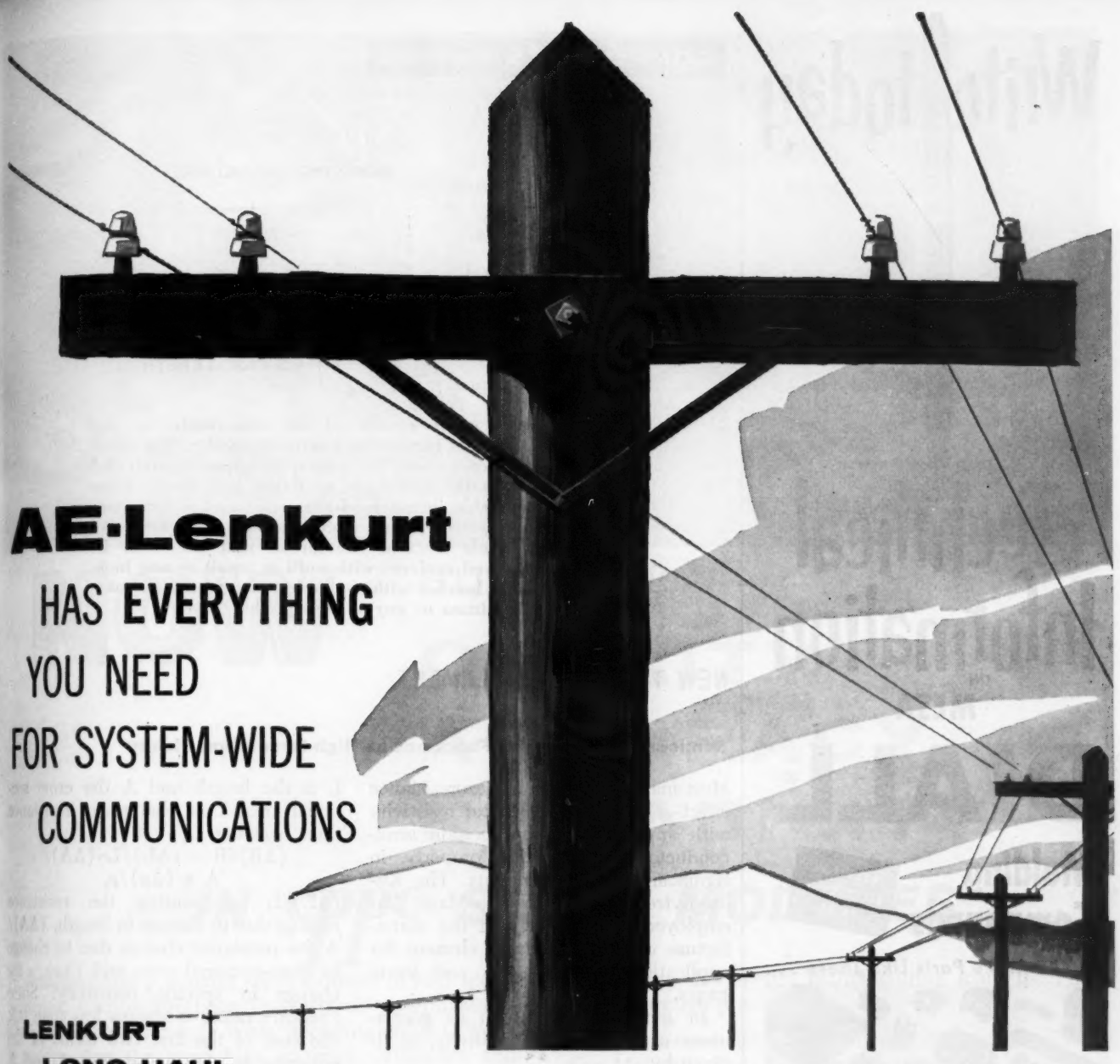

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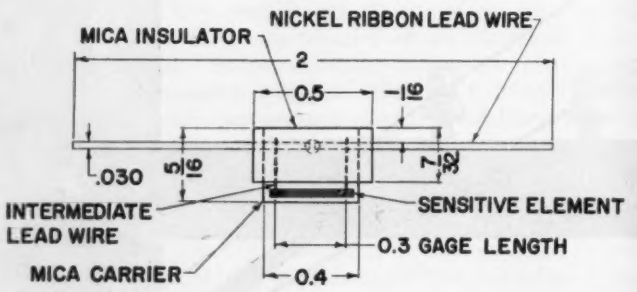


Kulite Bytrex gages consist of the semi-conductor and attached lead wires bonded to a suitable carrier. The semiconductor is very small; for example, approximately 0.3 inch long by 0.010 inch wide by 0.005 inch thick. Some units are available in much smaller sizes and without carriers. With reasonable care, gages are easy to handle and have been made flexible enough so that they can be applied to curved surfaces with radii as small as one inch. Bridges can be bonded with available cement such as Bakelite, Allen, Eastman or any of the epoxies.

NEW TRANSDUCER ELEMENT

Semiconductor Crystal Functions as High Resolution Pickup

Most materials exhibit a piezoresistance effect—a change in electrical resistivity with applied stress—but certain semiconductors possess this property in significantly larger amounts. The Kulite-Bytrex Corp., Newton, Mass., has employed this property in the manufacture of a new sensing element for application in transducers and strain gages.

In semiconductors such as germanium or silicon the resistivity, ρ, is given by

$$\rho = 1/(en\mu_{ave})$$

where e is the electronic charge, μ the number of carriers, and μ_{ave} the average mobility. The effect of an applied stress changes both the number of the charge carriers and their effective mobility, the magnitude and sign depending on the material and the orientation of the applied stress to the crystal axis.

Piezoresistance coefficient is defined as the fractional change in resistivity for a given stress. If the electric field, the current density and a simple tension are all in the same direction, then

$$(\Delta\rho)/\rho = \pi eT$$

$\Delta\rho$ is the change in resistivity, T the tension and πe the piezoresistance coefficient along the crystallographic direction in which the tension is applied.

A thin bar cut in the proper direction from a single crystal of germanium or silicon can be used as an ordinary strain gage. The resistance of the bar may be expressed as:

$$R = (\rho L)/A$$

L is the length and A the cross sectional area. Unit changes of resistance then becomes

$$(\Delta R)/R = (\Delta L)/L - (\Delta A)/A + (\Delta\rho)/\rho,$$

$(\Delta L)/L$ representing the resistance change due to change in length, $(\Delta A)/A$ the resistance change due to change in cross-sectional area; and $(\Delta\rho)/\rho$ the change in specific resistivity. Since Poisson's ration is always less than 0.5, the sum of the first two terms of the equation is always between 1 and 2.

Introducing Young's modulus and simplifying we get

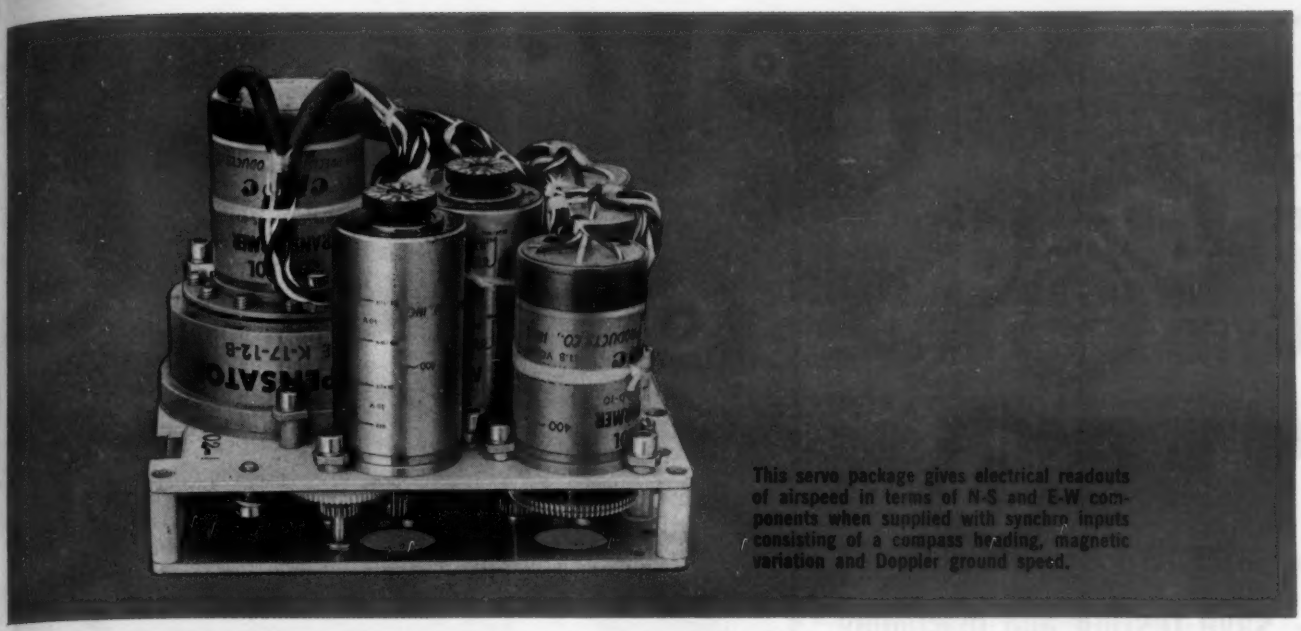
$$(\Delta R)/R = (1 + 2\nu + \pi_e E)\varepsilon$$

or

$$\Delta R/R\varepsilon = 1 + 2\nu + \pi_e E,$$

ε is the unit strain, ν Poisson's ratio and E Young's modulus. $\Delta R/R\varepsilon$ is called the gage factor. Most of the commonly used metal strain gages have gage factors between two and four, while germanium and silicon crystals have gage factors greater than one hundred because of their large piezoresistance coefficients.

According to Stanley Charren, Kulite-Bytrex's President, the most probable area in which these sensitive pickups will solve designers' problems will be in the development of highly sensitive dynamic transducers. "It is possible to build load sensing and pressure sensing devices whose total deflection at capacity load is in the order of micro-inches. This extremely low deflection permits assembling total systems with high natural frequency.



This servo package gives electrical readouts of airspeed in terms of N-S and E-W components when supplied with synchro inputs consisting of a compass heading, magnetic variation and Doppler ground speed.

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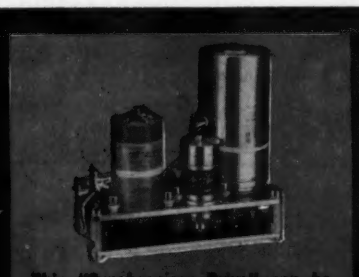
Clifton Heights Pennsylvania

This "Synchronizer Drive" servo package is used to null out gyro signals before an aircraft's autopilot is engaged.



This "Synchronizer Drive" can be used to null out transmitter signals. A wide variety of gear ratios is available as well as the option of two speed operation.

This transducer servo package converts a mechanical shaft input into a linear precise electrical output when a 28v dc signal is applied. It is particularly useful in aircraft for position information transmission of air surface controls.

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Components shown above—Synchro, Torquer and Spin Motor—are typical. Their specifications are tabled below. Other Ketay gyro component "packages" are Induction Pickoffs, Pancake Resolvers, D.C. Spin Motors and a unique D.C. Voice Coil Torquer giving a linear force of .55 grams per milliampere of current.

TYPICAL SPECIFICATIONS

SYNCHRO TRANSMITTER TYPE SP-152

Input Voltage (to Rotor)—400 cps—volts	26
Input Power—watts	1.0
Input Impedance (stator shorted)	110+j 36
Input Impedance (stator open)	89+j 230
Transformation Ratio	.454
Output Impedance (Rotor open)—ohms	27+j 44
Output Voltage—volts (line to line)	11.8
Voltage Gradient—volt/degree	0.206
Total Null Voltage (mv. max.)	30
Electrical Accuracy (Max. Error from E.Z.)—minutes	±3.0

(Tighter accuracy tolerances available for applications requiring limited ranges of rotation.)

A. C. TORQUER MOTOR TYPE SP-170

	Fixed Phase	Control Phase
Rated Excitation Voltage—volts	26	40
Frequency (cps)	400	400
Current—(mv.)	230	226
Power—watts	3.1	4.6
Power Factor	.517	.505
Resistance—ohms	58.5	89.3
Reactance—ohms	85.5	152.5
Impedance—ohms	113	177
Effective Resistance—ohms	218	348
Capacitor for Unity Power Factor—mfd	1.35	2
Torque at stall (min.)—oz.in.	1.0	

Operating Temperature Range—minus 55°C to plus 125°C

A. C. SPIN MOTOR TYPE SP-167

Input Voltage (line to line)—volts	26
Frequency—(cps)	400
Input Line Current (mv.) at stall condition	350
Total Input Power (watts) at stall condition (max.)	10
Input Line Current (mv.) at 24,000 rpm.	300
Total Power (watts) at 24,000 rpm. (nominal)	5.5
Stall Torque—(min.) in.oz.	.34
No-load Speed (rpm.)—(in air)	24,000
Run-up time with rated voltage (in air) to NLS—sec. max.	90
Moment of Inertia $Gm.Cm^2$	190
Angular Momentum $Gm.Cm^2/Sec.$ at 24,000 rpm.	475,000
Dynamically balanced to within $10x10^{-6}$ oz.in. max. unbalance	
Coasting time (in air) (min.)	2½
Total weight—gms.	151

Ambient Temperature Range—Minus 55°C. to Plus 125°C.

NORDEN

KETAY DEPARTMENT

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION
Commack, Long Island, New York

CIRCLE NO. 13 ON INQUIRY CARD

Current applications for the device are in:

- measurements of very low strain;
- measurements where the extremely high output—up to one volt—makes instrumentation simple or less expensive, as in telemetering, direct reading oscillographs and other units;
- measurements of elevated temperatures under restricted conditions;
- measurements under water or in areas where waterproofing becomes difficult.

Mr. Charren emphasized, "New applications of this device will take advantage of its extremely high output in the form of control devices which work directly into relays and control circuits without the use of amplification. The most apparent disadvantage of this device is its extremely large temperature coefficient. In environments where the temperature changes over a small range (±20F) this consideration is not important for control applications where 2 to 5 percent are satisfactory. In control applications where higher precision is required it is possible to build crystals whose resistance change with temperature is such as to offset the decrease in sensitivity of gage factor so as to provide a compensated network against temperature. Obviously, in the last analysis, it is a simple matter to maintain temperature of a controlled detector through the use of some simple thermal switches or compensating circuits."

The resistance of the device can be varied by adjusting the physical dimensions of the strain sensitive material by adjusting its resistivity. Special units are available with resistances from ohms to megohms in the same physical dimensions.

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WORTH FILING

Relays

Said to be the most complete listing of relays ever published, a catalog contains over 20 leading relay manufacturers' lines with complete description and prices. Thumb-indexed table of contents speeds the finding of any relay desired.

Source: Relay Sales, Inc., W. Chicago, Ill.

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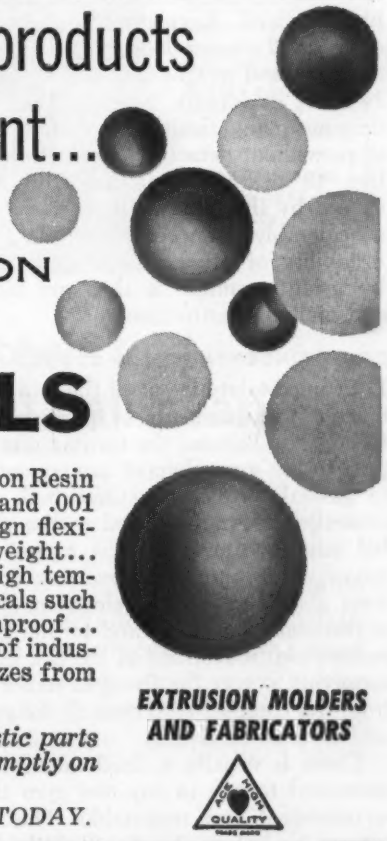

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- a ceramic material as hard as sapphire that can be diamond-honed into the tiny and ultra-precise shapes of critical gyro parts, and
- a miniature ceramic self-generating gas bearing

have sharply reduced the prime causes of gyro drift uncertainty. The ceramic bearings are lubricated by a film of gas only 25 millionths of an inch thick. Although virtually friction free, the gas film is under pressure that is stiffer than the steel ball bearings it replaces. At the same time vibration, or bearing noise, is decreased by a ratio of 30 to 1.

Although the principle of the gas bearing is not new, previous models without ceramics have been severely limited due to size and bearing wear caused by starting and stopping.

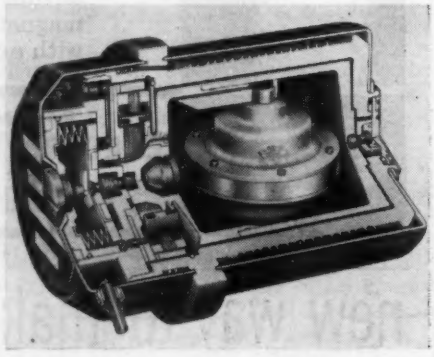
The new gyro developed by the Aeronautical Division of the Minneapolis-Honeywell Regulator Company is only 2.817 inches long, 2.0 inches in diameter and weighs only half a pound. In tests, its ceramic bearings have undergone many thousands of starts and stops without detectible wear. In addition to nearly eliminating the drift caused by the ball bearings, they have considerably reduced drift caused by instability of other critical gyro parts by using ceramics in the spin motor and gimbal constructions.

DRIFT UNCERTAINTY FACTORS

Drift uncertainty is one of the most significant measurements of performance for a gyro. Because the turning rate inputs to the gyro element are converted to gimbal torque, any unwanted, uncontrolled torques applied to the gimbal introduce errors in the output response. Unwanted torques may come from gimbal unbalance, electromagnetic reactions of pickoffs and torque generators, elastic restraint of the flex leads supplying power for the spin motor or from the complex responses of the gyro under vibration inputs.

There is usually a fixed amount of unwanted torque in any one gyro that is consistent and repeatable. This error can be balanced out with little difficulty by trim adjustment. Magnetic restraint and flex lead elastic restraint are typical types of this fixed torque.

However, the gyro designer is still left with some unwanted torques that cannot be compensated because they are inconsistent. The latter torques establish the true uncertainty level of the gyro and set performance limits for gyro drift. The ceramic gas bearing gyro has shown significant results in the control of these inconsistent torques. It has proved to be the solution to torques resulting from movement of the ball retainers and shifts of the balls in the race way, mechanical hysteresis effects due to material damping and ball slippage, and stress



Cutaway drawing shows details of new gas bearing gyroscope introduced by Minneapolis-Honeywell. Bell-shaped part in cavity is ceramic spin motor. Interior film of helium gas only 25 millionths spins at 24,000 rpms suspended on a of an inch thick.

and strain of the balls under angular motions of the gyro which cause deformations that change the balance of the gyro, and mechanical rectification of the vibrations set up by the ball bearings of the spin motor.

In the ceramic gas bearing gyro the troublesome balls and retainers are eliminated, viscous damping is substituted for hysteresis damping and deformations due to thermal expansion disappear.

Write No. 547 in Box on Inquiry Card

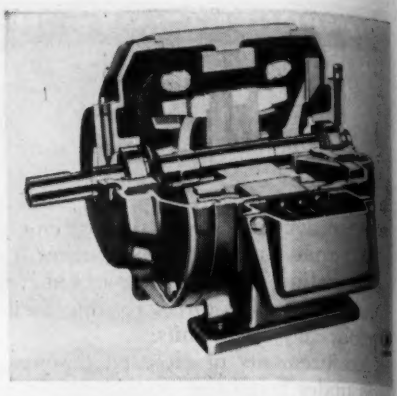
WORTH FILING

Ultrasonic Cleaning

12 case histories describe standardized ultrasonic cleaning applications for electronic, electromechanical and mechanical components.

Source: Acoustica Associates Inc.
Garden City, N.Y.

For your copy: Write No. 551 on Inquiry Card



ENCAPSULATED MOTOR

Epoxy System Produces High Resistance Properties

Class "B" ac motor insulation system, built around a thisotropic epoxy resin, is applied by a vacuum impregnation process. The insulation system employs polyester round copper magnetic coil wire, epoxy-insulated glass fibre sleeving, epoxy-treated glass fibre cloth slot liners and phase insulation. Separators and top sticks are glass mat base epoxy resin laminate, and lead cable is protected by moisture-proof silicone rubber. Stator windings are thoroughly encapsulated for resistance to moisture, oils, dust, chemicals, acids and alkalies.

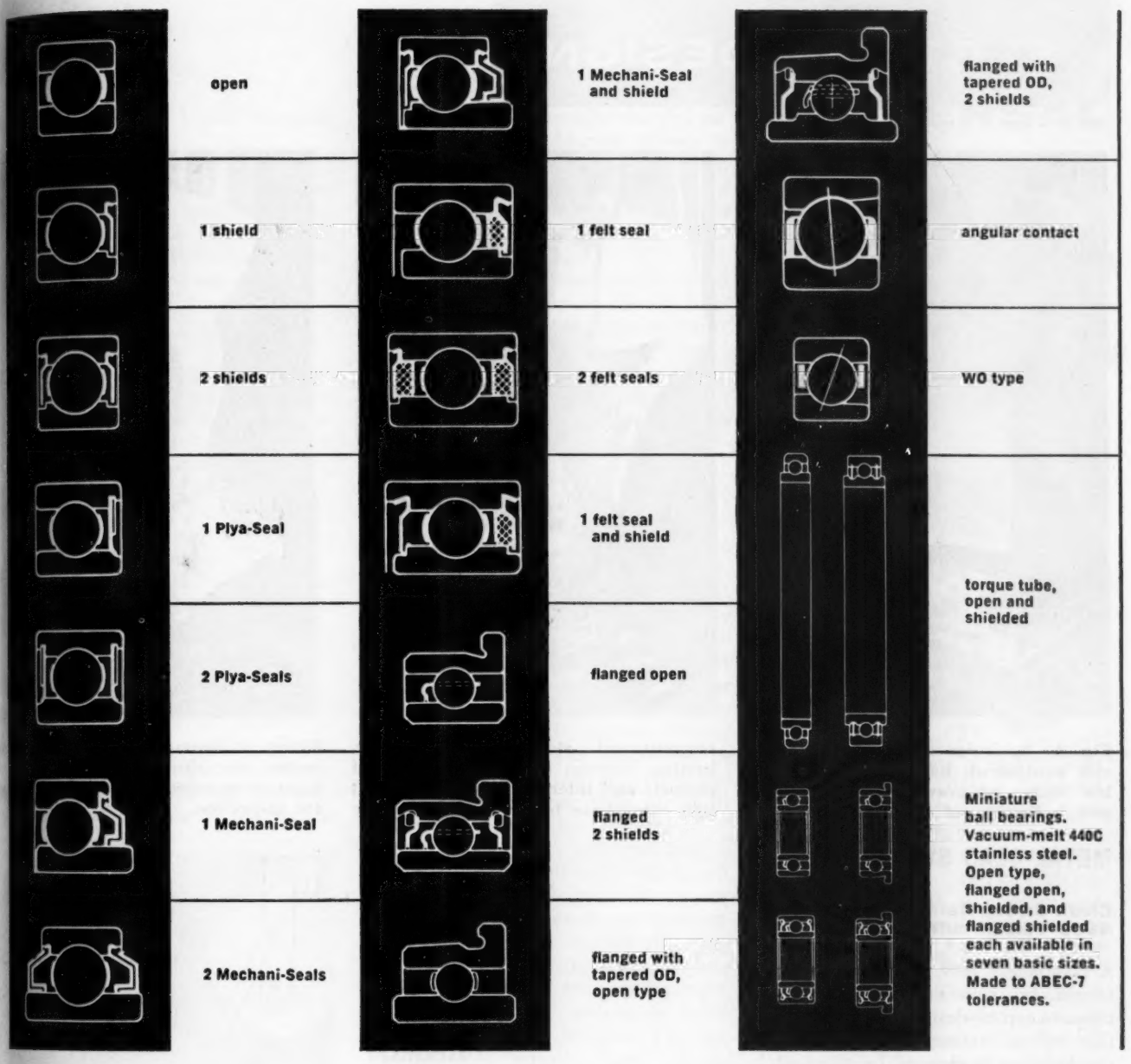
In the vacuum impregnation and pressure process, the wound stator core is pre-heated to drive out gases and moisture and then placed in a pressure vessel to be vacuum-drawn. Epoxy resin is then introduced into the vessel to submerge the winding. The vacuum is maintained to allow the resin to penetrate the coil slots and heads. Next, pressure is applied to the submerged core. The stator, now encapsulated in a solid, void-free protective insulation, is removed from the pressure vessel, drained, and baked in curing ovens.

The motor, protected in a solid cast-iron frame, exceeds splash-proof motor specifications. Cast iron conduit box is diagonally split with a gasketed cover for easy access to leads. A neoprene gasket between the motor housing and conduit box holds the numbered leads by means of pressure knobs.

A "metermatic" lubrication system is employed with the deep-groove, double-shielded ball bearings. A metering plate helps keep out contaminants while regulating the precise flow of fresh grease to the bearing as needed. Neoprene slinger on the pulley end of the motor and a shaft cap on the opposite end prevent the entry of moisture and foreign matter along the shaft.

Motors are currently available in frames 180 through 445V (one through 125 horsepower) in all standard speeds and voltages. Reliance Electric and Engineering Co., Cleveland, Ohio.

Write No. 178 in Box on Inquiry Card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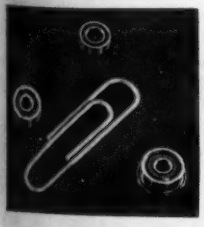
2 shields
1 Piya-Seal
2 Piya-Seals
1 Mechani-Seal
2 Mechani-Seals
1 Mechani-Seal and shield
1 felt seal
2 felt seals
1 felt seal and shield
flanged open
flanged 2 shields
flanged with tapered OD, open type
flanged with tapered OD, 2 shields
angular contact
WO type
torque tube, open and shielded
Miniature ball bearings. Vacuum-melt 440C stainless steel. Open type, flanged open, shielded, and flanged shielded each available in seven basic sizes. Made to ABEC-7 tolerances.

Fafnir has the types, sizes, seals, steels and tolerances you need in precision instrument ball bearings!



When you need ball bearings for instruments or precision mechanisms, you'll find ready answers at Fafnir.

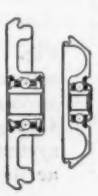
The Fafnir line includes all popular types. Sizes range from .3125 O.D. in the miniature series to 2.8750 O.D. in torque tube type bearings. You also have a wide choice of seal and shield arrangements, retainer designs, and tolerances together with a variety of steels to meet your most exacting requirements.

And you can count on Fafnir for dependable supply and uniform high quality. Fafnir's instrument bearing division is equipped with the most modern facilities for volume production, including bearing assembly, testing, and inspection. Write The Fafnir Bearing Company, New Britain Conn.

Fafnir special shafts and endbell bearings . . .

Assemblies comprised of special shafts with an angular-contact inner race ground on each end can be supplied with outer ring, ball, and retainer assemblies of the separable type or with endbells.

A major step forward in miniaturization, higher speed, and better precision are these gyro rotor bearings built integrally into the end bell. Fafnir will gladly work with designers on such special configurations.



FAFNIR BALL BEARINGS

CIRCLE NO. 16 ON INQUIRY CARD

Fig. 1 Re-designed for compact 4160 volt equipment, has lower weight and low center of gravity, closed drawout and indication of breaker position in compartment, stored energy closing, ironless blowout and foster closing of contacts and interruptions of faults. At left, interphase barrier is removed by lifting it from base of breaker. At center, arc chute is tilted and lifted from pivot point. At right, breaker tilted for inspection.

METAL-CLAD SWITCHGEAR

Clean-Sweep Re-design of 4160-Volt Circuit Breakers

A completely new design of 4160-volt circuit breakers and switchgear—first clean-sweep re-design of equipment in this voltage rating in the history of the industry is claimed by the switchgear division of I-T-E Circuit Breaker Company, Philadelphia. The breakers, first to combine stored-energy closing and ironless blowout in this voltage rating, afford faster fault interruptions and faster closing of contacts, and smaller size than any other comparable equipment available today in the 4160-volt field.

Major advances of the new circuit breakers include:

- *Stored-energy closure* – employs a motor-charged, spring-powered mechanism which provides faster closing of contacts, improves contact life and affords greater safety for personnel. Stored-energy closing principle is the same as that employed by I-T-E in its low-voltage K-Line power circuit breakers introduced in 1957.
- *Ironless blowout*—provides a significant reduction in arc chute weight for easier handling and faster fault interruptions through the improved arc ex-

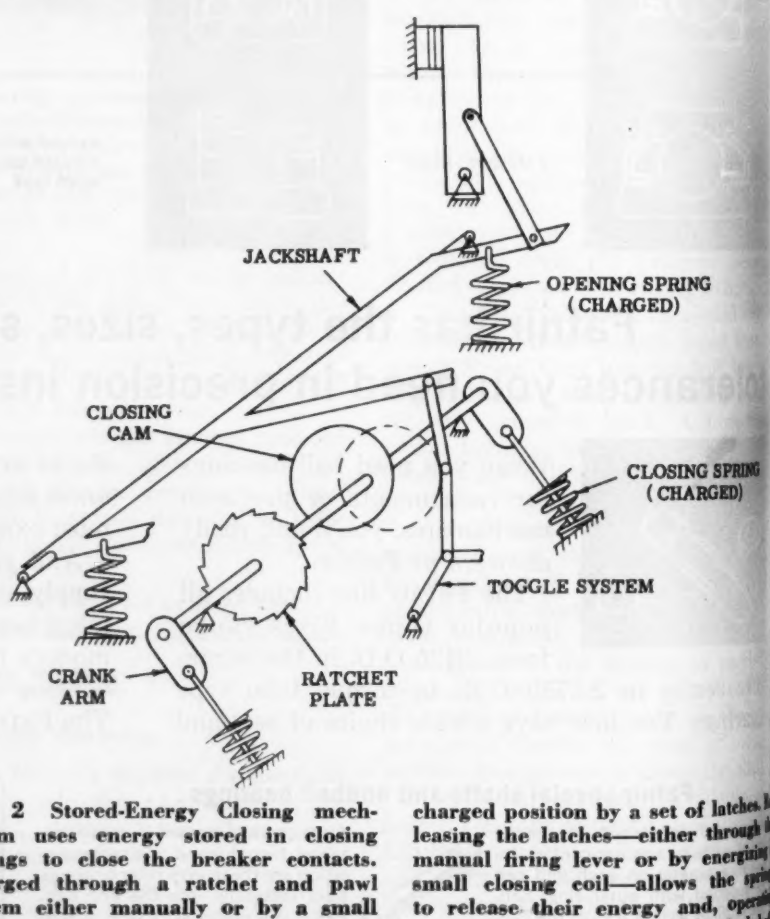


Fig. 2 Stored-Energy Closing mechanism uses energy stored in closing springs to close the breaker contacts. Charged through a ratchet and pawl system either manually or by a small ac/dc motor, the springs are held in charged position by a set of latches. Releasing the latches—either through a manual firing lever or by energizing a small closing coil—allows the springs to release their energy and, operating on a toggle system, lift the jackshaft

tinction afforded by better magnetic field distribution.

• *Compact size, low center of gravity* —permits smaller size of switchgear and easier and safer handling during installation and service. Because of its light weight, the breaker can be handled by one person for maintenance.

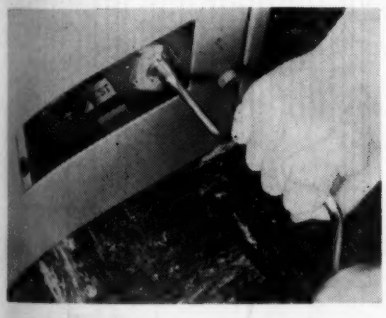
STORED-ENERGY CLOSING

The spring stored-energy system is inherently faster than other mechanisms on available breakers and does not introduce or cause the hesitation in action prevalent in other systems, according to I-T-E. Because the system is positive in action, involving no gravity action, the breaker may be operated in any physical position.

The motor and ratchet arrangement provides simplicity and long life. The slip-tooth ratchet allows free-wheeling so that the motor coasts to a stop and is not subjected to jolts or shocks produced by sudden stops. System uses no clutches or brakes and introduces no complicated motor cutoff problems.

Constant contact closing force is also assured by the stored-energy approach; no change takes place in the springs and they can be manually charged for emergency closing. Manual closing is available with the door closed by using a lanyard tied to the manual closing hook. For maintenance purposes, with breaker outside the compartment, contacts can be slow-closed.

Control power requirements have been cut drastically—to about one-tenth of the current required by other types of actuating systems. Control voltage can be supplied from any normal lighting circuit—such as 115 or 230 volts ac—or from a 48 to 250 volt dc supply.



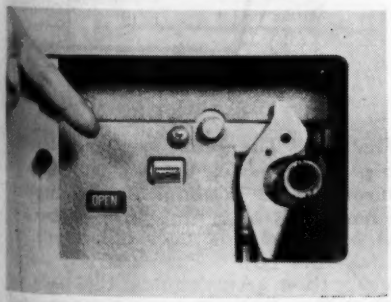


Fig. 3 Closed-Door Drawout from connected to test and disconnected positions permits doors to be kept shut affording maximum safety for personnel; aisles are also kept free from obstructions to the passage of people and equipment. Indicator on floor (upper photo) shows breaker position—connected, test, disconnected—with doors closed. Another indicator (lower photo) on breaker shows contact status—open or closed.

IRONLESS BLOWOUT

Face-wound blowout coils—one of the most radical advances in the new breakers and in the circuit breaker art —provide manifold advantages. They include faster, more efficient interruption without the time lag that occurs when iron is used. This results in far less deterioration of the entire interrupter system and smaller, lighter weight arc chutes. The chutes can be tilted easily for contact inspection and maintenance and they snap off easily and can be carried by one man.

The light-weight coils produce a high-flux-density, uniformly distributed, in-phase field which pulls the arc up into the chutes faster—to cut interruption time, increase contact life and reduce erosion of chutes. An extremely effective, silent and long-lasting pneumatic puffer-buffer system is incorporated on the new breakers. The puffer provides equally fast, efficient interruption on low-current openings. In reverse, it acts as a buffer to lessen shocks occurring during the contact opening.

BREAKER CONSTRUCTION FEATURES

New design breaker contacts are made virtually maintenance-free, with arcing contact surfaces of high refractory silver alloy—for minimum deterioration under arcing. Main contacts are a silver alloy which provides excellent electrical conductivity. All contacts afford abundant wiping action to insure proper contact. A screw on the movable bridge adjusts contact travel. Use of a high-pressure hinge eliminates the need for a braided pigtail shunt—removing a possible source of trouble.

The new breakers fully extinguish arcs within five cycles. Arcs are forced up into extinguisher plates of special ceramic material developed for this

put HEINZE in your designs

HEINZE UNIVERSAL MOTORS

are VERSATILE

An endless variety of modifications are available on Heinze Universal Motors, such as stainless steel shaft . . . special cuts on shafts such as worms, pinions, screw threads, cross holes, flats, etc. . . . double shaft extension . . . cord sets . . . inline switches on cord sets . . . ventilated cases . . . fungus proofing . . . various type leads . . . choice of color.

In addition, Heinze Universal Motors are rugged to withstand tough applications, compact to fit limited space, have high starting and running torque, variety of mounting arrangements, are uniform in quality, keyed to high production, and are competitively priced.

Standard voltage rating is 115V AC/DC but motors are supplied for other voltages.

Send coupon for catalog.

HEINZE **ELECTRIC COMPANY**
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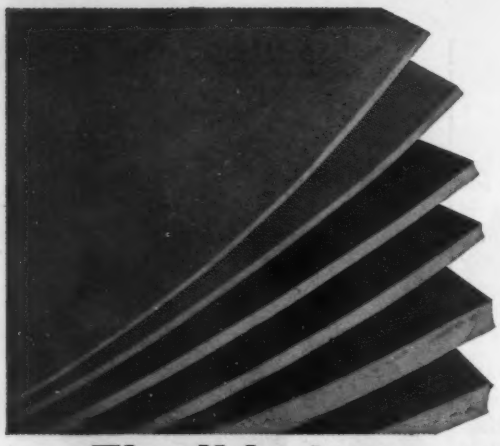
City and State.....

CIRCLE NO. 19 ON INQUIRY CARD



SILICONE SPONGE RUBBER SHEETS

Flexible temperature range -100°F to 500°F

COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening. Meets many specifications.
AVAILABLE FROM STOCK: in 12″ x 12″ sheets and 24″ x 24″ sheets — 1/16″ through 1/2″. Special thicknesses and sheet sizes up to 30″ x 30″ and 24″ x 48″ made to order. Sold nationally through distributors.

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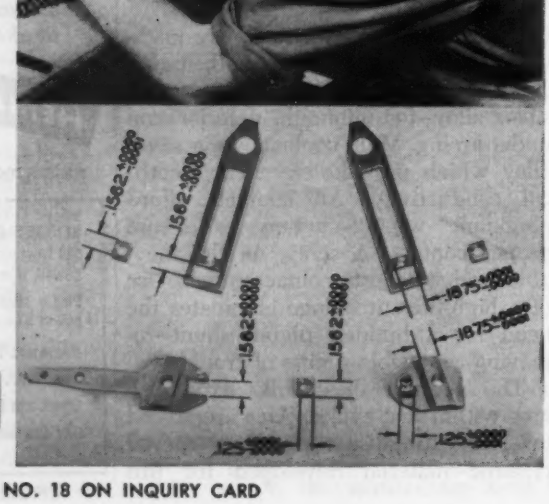

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HOB

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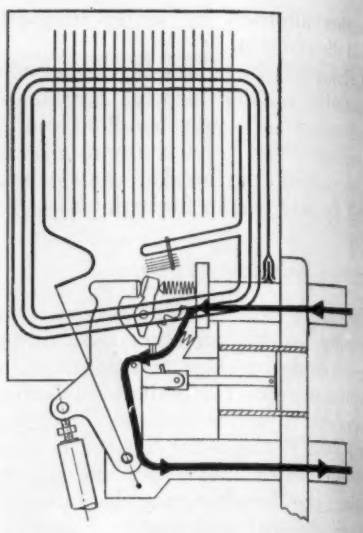

Fig. D-1 Schematics illustrate interruption of the 5HK breaker; when breaker contacts are fully cosed and an abnormal condition appears in the circuit, a protective relay designed detects the abnormality and energizes the shunt trip.

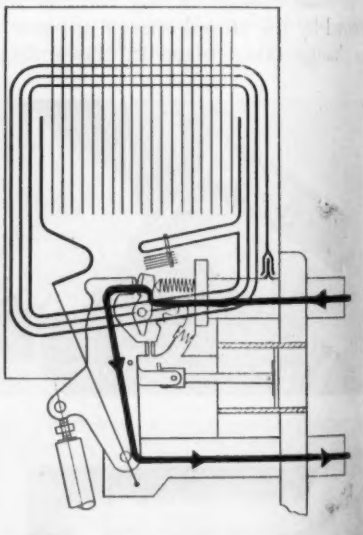

Fig. D-2 The shunt trip operates the trip lever, causing the mechanism to go through its mechanical tripping sequence and open the main contacts.

application. Arc chutes tilt back by hand for inspection of contacts and chute interiors. Chutes can be removed easily without tools and can be carried by one man. Self-aligning primary and secondary disconnects are attached to the breakers so that they are accessible with safety. Conservatively designed lockwound, multiple springs on primary disconnects assure good contact.

The three primary lead and arc chute supports are one-piece, high-

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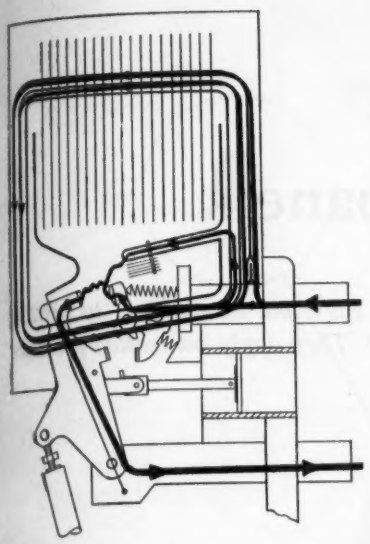

Fig. D-3 Continuing to open the mechanism opens the arcing contacts establishing an arc. Under natural thermal action and the action of the puffer, the arc rises and is transferred to the arc runners. The puffer is a nozzle-piston device attached to the contact arm. It directs a blast of air through the contacts into the arc chute on the opening stroke of the breaker and is the primary means of extinguishing arcs of currents below 1000 amperes.

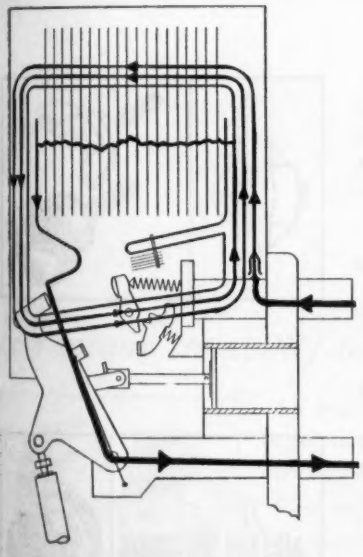

Fig. D-4 Transference of the arc to the arc runners energizes the "Face Wound" blowout coils that consist of two copper coils, one molded into each arc chute side plate and connected in series. The absence of iron eliminates the time lag in establishing a magnetic field that drives the arc into the arc chute plates where it is stretched and cooled to a point where at some early current zero it can not re-establish itself.

strength moldings of flame-retardant, track resistant polyester glass, avoiding the use of any grounded metal above the chassis. The special polyester exhibits track resistance several hundred times that of ordinary polyester.

Write No. 153 in Box on Inquiry Card

Digital Decommutator

Solid-state, completely digital telemetry decommutator accepts most pulse-type signal inputs, PAM, PDM, or PCM, over a wide sampling-rate range of 10 to 4600 pps, and provides digital or analog outputs. PCM bit rates (serial) to 60,000 bits per second and word lengths of 16 bits (serial or parallel) can be handled. Between 10 and 128 channels or words per frame can be accommodated. Outputs can be multiplexed parallel binary for tape recording; decommutated binary for computer or printer; or analog for driving pen recorders and similar devices. For digital outputs, accuracy is 10 bits (0.1%) at sampling rates up to 1150 pps and eight bits (0.4%) at higher rates, per eight bits over the entire range. Linearity is better than the digital-system resolution. Electro-Mechanical Research, Inc., ASCOP Division, Princeton, New Jersey.

Write No. 335 in Box on Inquiry Card

Vibration Testing

Conceived as a single unit or "package," a vibration table, called Duopower, incorporates a slip plate or table between two shaker heads to eliminate power loss due to coupling equipment. Although the table was designed to vibrate in a horizontal plane, testing in a vertical plane is possible merely by using a "knee" mounted to the table. Operation of the two shaker heads in a push-pull manner produces a more equally-distributed first vibration as well as a truer picture of complex motion. Elimination of many expensive test fixtures permits a greater working area. Westinghouse X-Ray and Industrial Electronics Division, Baltimore, Md.

Write No. 559 in Box on Inquiry Card

WORTH BUYING

Printed Circuits

59-page report contains a number of independent studies made by major suppliers of military electronics and findings of test laboratories on the reliability of plated-thru holes employed in printed wiring boards. Included in the report are listings of large military programs and their prime contractors now using and planning to use plated-thru holes. Charts and illustrations highlight the results of comparison and laboratory studies. Price: $1.00. Order your copy from:

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A Peep at the Next 2 Months

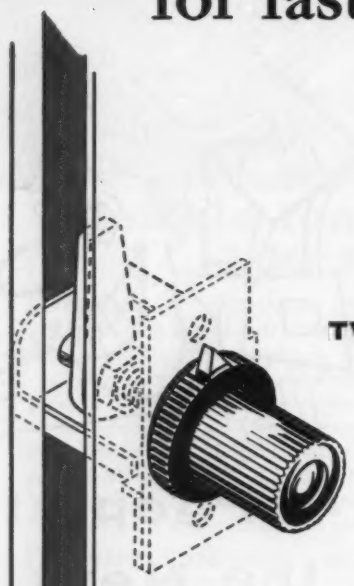
in august . . .

Last May we published a Design Time Saver on fastening designs for speed, inserts, safety, simplicity, appearance, adjustment and sealing. In August we shall present part 2 of this Design Time Saver. In addition to another important collection of fastening designs in the above categories we shall be including head and point terminology for fastener selection; and platings and finishes for fasteners, organized in tabular form for ready selection and reference.

in september . . .

A continuation of our running series on magnetic amplifiers, Part 3B deals with audio power magamps. This section discusses the practical problems in using magnetic amplifiers. More specifically, we're presenting six popular circuits that cover a wide range of types but predominantly fast circuits that drive two-phase servo motors. We're going to present in quick reference form all six circuits, nomenclature, waveforms, formulas, Fourier analysis and pertinent remarks associated with each of the circuits. And in addition a complete tabulation of available magamps.

Standards with unique features for fastening doors and panels

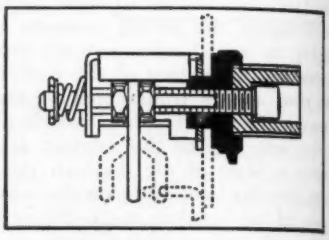


Southco adjustable pawl fasteners are easy and economical to install, give a "class" appearance to equipment. They apply controlled pressure to seal tightly and stop rattles.

TWIN KNOB CONTROL—NO. 46

The pawl engages the frame when the actuator is turned 90°. A bright chrome button in the center of the knob is preset for the amount of pressure to be exerted by the fastener. After the pawl engages the frame, the knob is turned until the button is flush with the knob surface. Preset pressure is thus obtained.

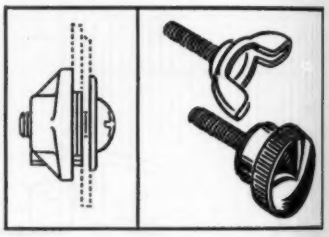
Materials *Body: Cadmium plated steel*
Knob: Black nylon



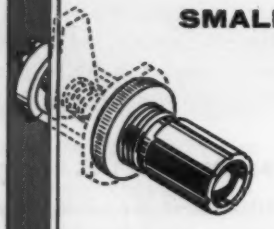
MINIATURE ENVELOPE—NO. 45

Requiring a minimum of space inside and outside, this fastener latches on a ¼ turn and additional turning pulls up the door or panel against its frame. The nylon pawl operates smoothly against metal and provides exceptional wearing qualities.

Materials *Pawl stop and washers: Carbon steel, cadmium plated*
Pawl: Nylon, natural

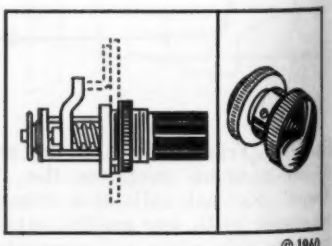


SMALL, HEAVY-DUTY MOUNTING—NO. 48



Small, rugged, compact. One quarter turn closes, additional turning tightens. Quickly installed with a single mounting nut. Three sizes cover every frame thickness from .000 to .750. Can be supplied with flatted shaft for your knob.

Materials *Body and pawl: Steel, cadmium plated*
Knob: Black nylon



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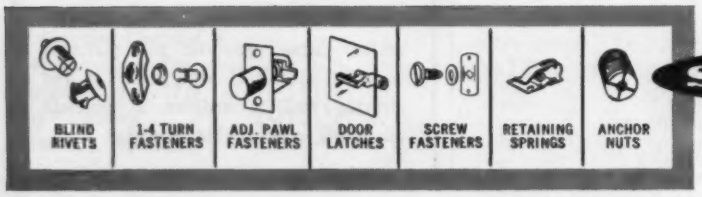
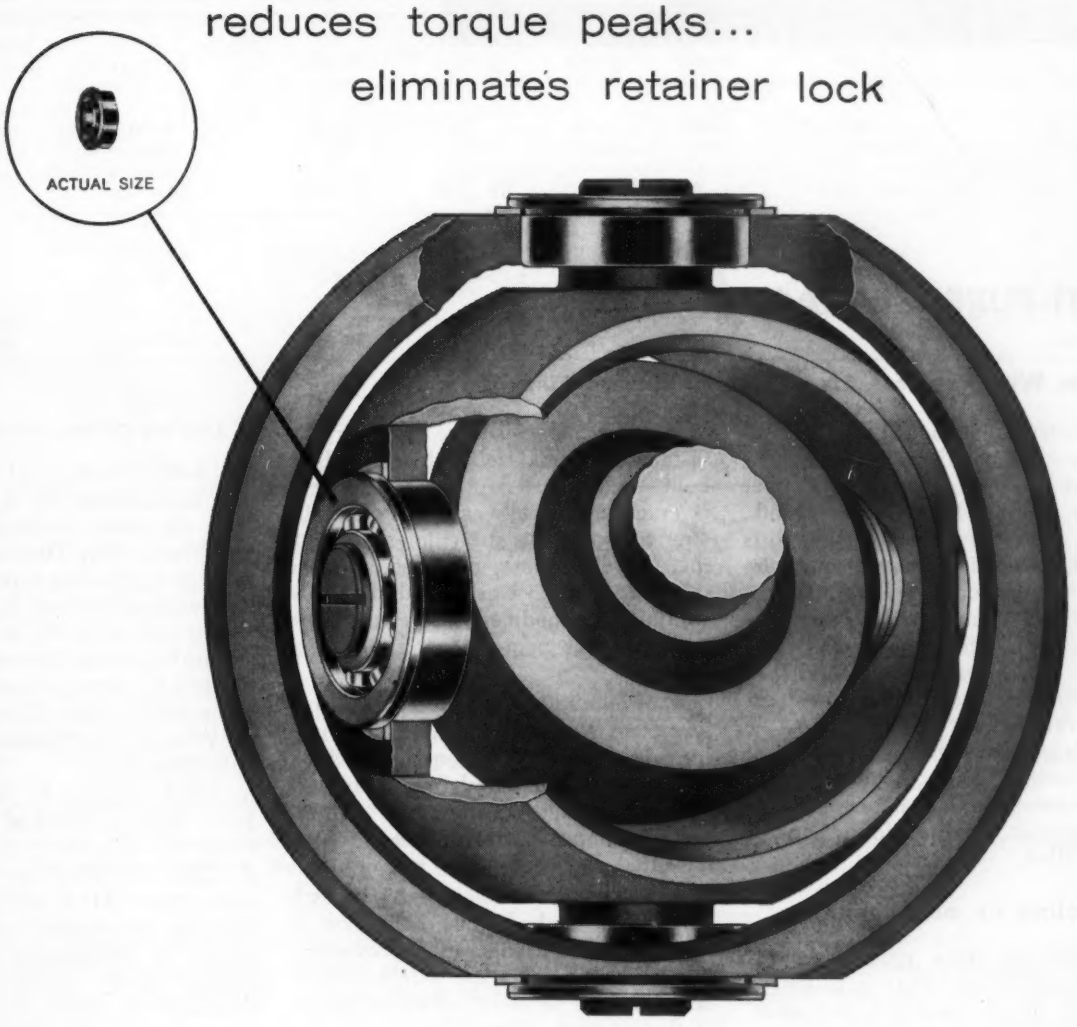


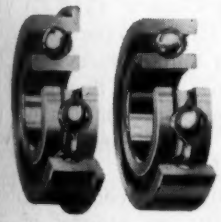
SOUTHCO FASTENERS
LION

CIRCLE NO. 4 ON INQUIRY CARD

BARDEN "W" retainer reduces torque peaks... eliminates retainer lock



Low-torque reliability for gyros, synchros and other torque-sensitive components



"W" retainer bearings are available flanged or unflanged, shielded or open, in sizes most in demand ⅝" O.D. and under. For complete technical information write for engineering data sheet W-1.

An instrument bearing that passes all normal torque tests can develop excessive torque peaks in operation. In gyro gimbals, synchros and similar applications the result is erratic component performance. To solve this reliability problem, Barden developed the "W" ball retainer.

Field tested and proved in actual operation, Barden "W" retainer bearings are specified for a growing number of torque-sensitive applications. • • • *In gimbals on the Sidewinder they contribute to the missile's reliability.* • • • *In attitude gyros they save one manufacturer $100 per unit by reducing costly teardown.*

Like other Barden advances in engineering and manufacturing, "W" retainers answer a specific performance problem. Other Barden Precision ball bearings satisfy such extreme demands as:

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- Concentric rotation (to .00005" max. T.I.R.)

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CIRCLE NO. 25 ON INQUIRY CARD

MULTI-PURPOSE MAGNET WIRE

One Film Wire Replaces Six or More Standard Films

The industry's first multi-purpose magnet wire, designated Poly-Thermaleze, a product of the Phelps Dodge Copper Products Corp., Fort Wayne, Ind., promises to reduce manufacturing costs by standardizing inventory to one wire for most applications. Phelps states that its new Class A through F magnet wire has physical thermal electrical and chemical properties equal to or better than any of the organic film wires currently available for coils, motors, dc field coils and armatures, all types of random-wound coils including solenoids, series wound armatures, epoxy encapsulations, and transformers other than oil filled.

BACKGROUND OF DEVELOPMENT

In the last five years, much emphasis has been placed on what is called "a polyester" or "a modified polyester" type film insulated magnet wire. Basically, these products are modifications of polymers based on Ethylene Glycol-Glycerine Terephthalic polyesters quite similar in chemical structure to sheet and fiber materials commonly known by tradenames as "Terelene", "Mylar", and "Dacron". The wire tradenames, and in some cases, varnishes based on these types of polyesters are known as Sylkyd, Isonel, Alkanex, Thermaleze F, etc.

Materials identified as Isonel 175 and Thermaleze F are specifically cross-linked polyesters using an isocyanate type of resin identified as "Mondur SH", a nonsolderable type of isocyanate that acts as a cross-linking agent to give improved thermal and chemical stability to the wire insulation. This product has been used in substantial quantities as a Class B (130 C) and Class F (155 C) magnet wire.

However, Thermaleze F had certain limiting properties when comparing it to some of Phelps Dodge's lower temperature rated wires such as Formvar, Nyform, Nyleze, Thermaleze B, Epoxy, and Sodereze. Briefly, these limiting properties were as follows:

- *Heat Shock*—Unlike Formvar, for instance, Thermaleze F when stretched, bent, and heated would "heat shock" or crack functionally as a lack of tensile strength when this stretching and bending, usually severe, occurred and the wire under strain was heated. The conventional unmodified polyester wire, however, was poorer than Thermaleze F.

- *Windability*—Comparing Thermaleze F to Nyform or Nyleze, Thermaleze F did not have quite as high abrasion resistance and frictional characteristics found in these other products. An improvement in this area was indicated.

- *Solvent Resistance* — Although Thermaleze F had good resistance to most varnish solvents, an improvement of the insolubility of the wire would be of advantage to resist softening action of the stronger solvents being used for magnet wire windings.

- *Cut-Thru*—An improvement in the form stability of wire for continuous operation at higher temperature was indicated.

Obviously, there were ways in which synthetic resins could be put together to improve individual properties, but Phelps Dodge's objective was to improve limiting properties without sacrifice of any basic properties in a full Class F wire. A sacrifice in thermal life by the addition of a nylon jacket, although of some obvious physical advantages, showed a serious sacrifice in dielectric life as measured by AIEE #57. The ideal wire, therefore, would be one that would not sacrifice thermal life, but which would improve any limiting property in the present Thermaleze F.

As a result of Phelps Dodge's development work with the objectives above, their research dep't developed Poly-Thermaleze, named to indicate its wide area of application particularly over the temperature ranges of Class F (155 C), Class B (130 C), and Class A (105 C).

Q AND A's OF POLY-THERMALEZE

To better understand the properties and applications for Poly-Thermaleze, here are some questions and answers:

Q. What is Poly-Thermaleze?

A. It is a polyester type of wire. Since it is well recognized that nylon (polyamide type resin 66) is subject to rapid air oxidation and deterioration at Class F (155 C) temperature, there was no nylon used in Poly-Thermaleze.

Q. What is the temperature rating of Poly-Thermaleze.

A. AIEE Standard No. I, revised, June, 1957, established a new Class F (155 C). Class B (130 C) and Class A (105 C) have been standard for some years. AIEE #57 dielectric twist tests on unvarnished samples are the means of determining the long time thermal life by establishing the rate of deterioration which can be used for extrapolation. By now, this procedure is well recognized. Under this procedure, the Poly-Thermaleze wire actually would extrapolate at 20,000 hours to a Class H (180 C) wire, but the dictates of good insulation system design indicate that Poly-Thermaleze should be rated as a Class F (155 C) wire, although in some properly designed systems higher temperatures than Class F for short times should be satisfactory.

Q. What about the comparative test properties of Poly-Thermaleze with other types of wires?

A. Phelps-Dodge has complete laboratory test results on samples of #18 Heavy Poly-Thermaleze selected to be typical of the product comparing it to Formvar (Vinyl Formal Phenolic), Thermaleze B (Epoxy Polyester), Nyleze (Nylon over Phelps Dodge Sodereze), Epoxy (Epoxide-Urea Formaldehyde), and Thermaleze F. This test data extends far and beyond normal comparative tests and includes many new tests developed in the Phelps Dodge laboratories to simulate service conditions more accurately. Using the test data as a criteria, their engineers state that the objectives of a develop-

PROPERTIES:	POLY-THERMALEZE	FORMVAR	NYFORM	EPOXY	NYLEZE	THERMALEZE B	THERMALEZE F
Phelps Dodge rating AIEE –57 procedures	155 °C	105 °C	105 °C	120 °C	130 °C	130 °C	155 °C
Abrasion Resistance: Repeated Scrape Unilateral Scrape	60+ 1400	60+ 1300	20+ 1600	20+ 1400	30+ 1700	20+ 1500	50+ 1300
Film Flexibility	20%–1X	20%–1X	20%–1X	20%–1X	20%–1X	10%–1X	20%–1X
Solvent Shock	20%–3X OK	20%–3X OK	20%–3X OK	20%–3X OK	20%–3X OK	10%–3X OK	0%–3X OK 10%–3X Fails
Solvent Resistance	Excellent	Good	Good	Fair	Good	Good	Good
Resistance to Freon 22	Good	Fair	....	Fair	....	....	....
Variable Pressure Cut-thru at 200 °C	30 lbs.	8 lbs.	10 lbs.	4 lbs.	16 lbs.	16 lbs.	17 lbs.
Constant Pressure Cut-thru at 2000 gm.	305 °C	205 °C	230 °C	200 °C	250 °C	325 °C	290 °C
Heat Shock at 150 °C	20%–3X OK	20%–3X OK	20%–3X OK	20%–3X OK	20%–3X OK	10%–3X OK 20%–3X Fails	0%–3X OK 10%–3X Fails
Dielectric Twist-volts per mil.	4000	3000	2500	3000	2500	3000	3000
Insulation Resistance in megohms after 10 min. water boil	500,000	200,000	100,000	200,000	200,000	500,000	500,000

Typical test results on #18 heavy grade wires demonstrate clearly that Poly-Thermaleze combines the outstanding properties of six or more conventional wires for motor, coil and dry-type transformer use.

ment of a wire of balanced properties for broad application have been accomplished. Copies of these test procedures are available upon request.

Q. In What Area is Poly-Thermaleze Different than Formvar (Vinyl Formal Phenolic)?

A. Poly-Thermaleze is basically a polyester and like many other organic materials can be hydrolized under severe conditions of water, high temperature, and higher than atmospheric pressure. Many organic varnishes and resins that have been used for many years in the electrical industry contain ester linkages and will, under severe conditions (pressure cooker), hydrolyze by a splitting of the molecule resulting in a change in physical properties. The rate of hydrolysis varies with the various products.

A simple, but severe, test to demonstrate the effect of hydrolysis is to *seal* the insulated wire or insulations in glass tubes containing small quantities of water. When these are heated to high temperature hydrolysis can occur and the results can be observed qualitatively. Under these conditions, Phelps-Dodge found hydrolysis or other damaging effects to occur in many common successfully used insulations. For instance, hydrolysis can be observed under the severe conditions of tests with the following well-known materials:—Mylar and Dacron—(Daglas), Nylons, Conventional Black Enamel (Oleoresinous), Linseed and Chinawood oil based varnishes, Thermaleze B (Epoxy-Polyester), Acrylic (Lecton—film wrinkles badly), Sodereze and Nyleze (Polyurethane-Polyester combinations), Silicones and Sylkyds, Bondar (Polyester Polyamide Epoxy), Polyester wires —Alkanex and Isonel, Thermaleze F and Isonel 175 (Polyester Cyanurate).

Many of the materials used for many years are subject to hydrolysis if the conditions are severe. Formvar and Epoxy (Epoxide-Urea Formaldehyde) are relatively more stable because they do not contain an ester linkage in the main chain. In the case of the Epoxy, however, Phelps Dodge found some breakdown of the amine which appears to attack the copper.

In the last five years, millions of pounds of polyester type wire have been used in electrical windings. There has been no evidence of hydrolysis because the conditions where water, high heat, and higher than atmospheric pressure were together did not exist, particularly in so-called totally enclosed motors because pressure buildup in the windings is relieved through the bearings.

Q. Where can't Poly-Thermaleze be used?

A. Poly-Thermaleze, since it is a polyester, does have certain areas of application where it is not recommended. Specifically, oil filled power and distribution transformers containing paper, from laboratory tests, have shown that the water of decomposition of the paper does affect polyester based materials at high test temperature (125 C to 150 C). Countering this observation is the fact that many products such as Black Enamel, "Bondar", oil varnishes, etc. that are far more subject to hydrolysis have been used satisfactorily.

Another area of application where another product may be a better selection is in hermetically sealed relays containing cellulose in the form of paper, cotton, etc. that at higher operating temperatures, from decomposition, would generate water which under higher than atmospheric pressure could start hydrolysis reactions.

A specific recommendation dictated by good insulation system design is to not use cellulose based materials in higher temperature windings, Class F (155 C) and Class B (130 C). This recommendation is based not only on the fact that cellulose will not stand these higher temperatures without serious embrittlement, but that they also can be a source of water and acidic de-

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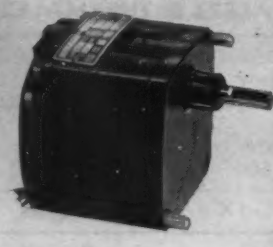

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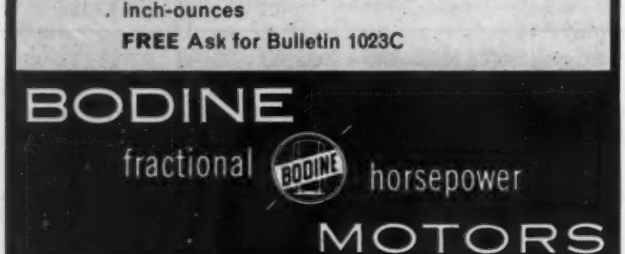

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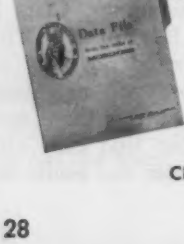

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4 MPB announces...

3 new R's of instrument bearings

3

2

Latest additions to the large, fast-growing MPB family are ultra-precision R2, R3, and R4 instrument bearings.

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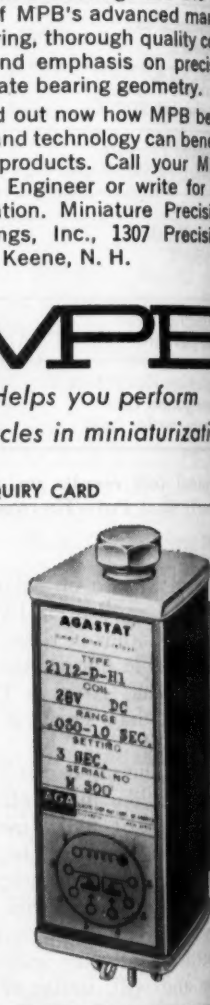

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composition products.

Q. What types of varnishes should be used with Poly-Thermaleze?

A. The AIEE #57 Dielectric Twist Procedure offers an excellent means of evaluating the effect of various types of varnishes on magnet wires. Varnishes to use with Poly-Thermaleze are similar to those used with polyester wires or Thermaleze F. Generally, a varnish of lower thermal rating than the wire will down-grade the complete system, whereas varnishes such as silicone based materials will match the thermal rating of Poly-Thermaleze.

Q. Is Poly-Thermaleze suitable for encapsulated systems?

A. Tests have been completed where dielectric twists were potted in nine different Epoxies and aged at 200°C. The results indicate that Poly-Thermaleze performs better than any of the other wires although some systems can seriously affect any type of wire.

Q. Is Poly Thermaleze suitable for use with chlorinated materials?

A. Chlorinated insulating materials like Polyvinyl Chloride and Neoprene are questionable in use at Class B (130C) and Class F (155C) temperatures primarily because in themselves they are not stable at the higher operating temperatures. At the higher temperatures decomposition occurs progressively depending on the amount of stabilizer causing the liberation of acids. For lower temperature windings where decomposition does not occur there is no problem.

In chlorinated refrigerants Poly-Thermaleze exhibits excellent properties normally used to test wire for hermetics. It has extremely low extraction, both in Methanol and Freon. It softens less in liquid R-22 than Thermaleze F or Formvar, but blisters somewhat under extreme test conditions as will other hermetic magnet wires.

Chlorinated liquids used in inflammable transformers do not soften Poly-Thermaleze.

Q. Is Poly-Thermaleze wire solderable?

A. Poly-Thermaleze will not solder, but rather carbonizes. Mechanical or chemical stripping methods, welding procedures, or mechanical pressure fasteners must be used.

Phelps Dodge engineers have run some fairly exhaustive tests on the properties of their new magnet wire and are making them available to interested engineers. The wire comes in a complete range of grades and sizes of rounds, squares and rectangular wire; price is the same as Formvar.

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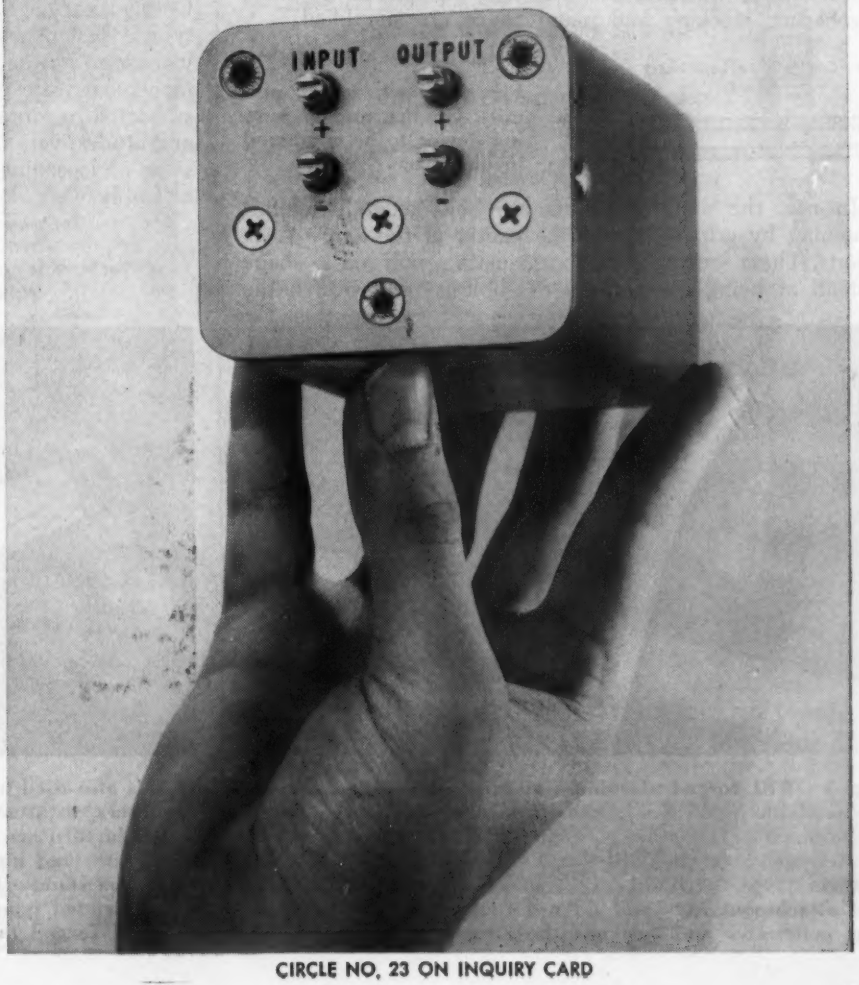

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NEW TECHNIQUES

VIBRATION-RESISTANT FASTENER

Locking Insert Helps Reduce Aircraft Costs By 30%

Supports for securing electrical wiring bundles, hydraulic tubing, plumbing lines and heater ducts in aircraft and missiles have been improved and installation costs reduced by 30% with Western Sky Industries' self-locking fasteners incorporating Heli-Coil (R) Screw-Lock inserts. Through the use of this locking insert, a locking device and mounting are combined in one piece (Fig. 1). WSI locking brackets reduce space requirements and increase rigidity and vibration resistance in aircraft and missiles.

Formerly, sheet metal clips and brackets were attached in various configurations to the airframe to support wiring and tubing. Special designs were required involving costly engineering time, special punch press tooling, expensive shop labor and frequent re-work to make them fit. Piping and wire bundles were fastened to clips with loop-type clamps which in turn were attached to the airframe by means of bolts, nuts, washers and lock wires.

Bits-and-pieces construction made clip-supports difficult to lay out and line up in intricate installations. The demands of increased hydraulic pressures and the tremendous strains imposed by water injection in jet engines created a need for fasteners that would withstand high vibratory and other stresses with positive retention of clamps and screws. By incorporating a Heli-Coil (R) Stainless Steel Screw-Lock insert, this goal was achieved in the WSI design. The fastener offers high strength with low weight and eliminates the need for troublesome brackets, spacers, tube spacers, taper washers, nuts and lock washers. In addition, purchasing, stocking and maintenance are simplified.

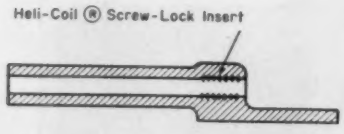

Fig. 2 Lock insert permits locking and mounting device to be combined in one piece.

In use, the mounting bolts are held securely against loosening by grip coils near the center of the Screw-Lock inserts. These locking coils approximate a polygon in shape instead of being circular. As the bolt is run through the insert, the grip coils are forced to conform to the thread circle. The resilient chords of the grip coils maintain a strong, spring-like pressure on the bolt, giving a locking effect which is not diminished through repeated disassemblies. The locked screw may be readily disassembled by applying breakaway torque approximately the same as assembly torque.

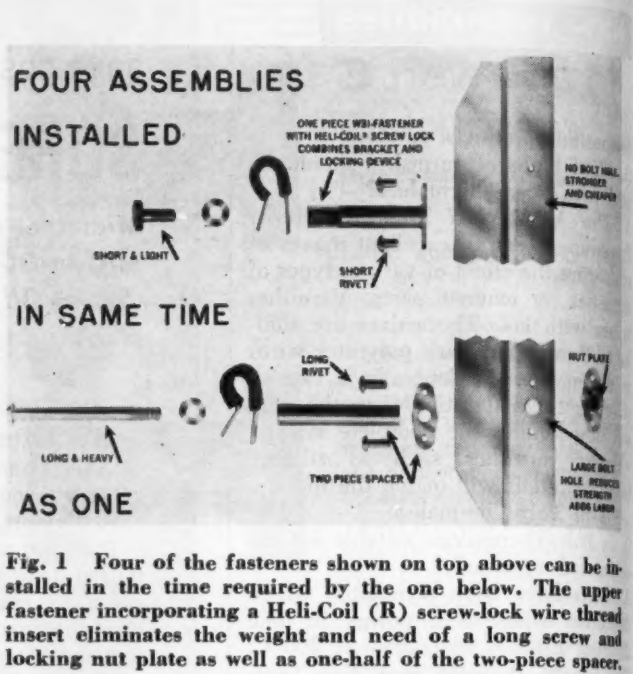

Fig. 1 Four of the fasteners shown on top above can be installed in the time required by the one below. The upper fastener incorporating a Heli-Coil (R) screw-lock wire thread insert eliminates the weight and need of a long screw and locking nut plate as well as one-half of the two-piece spacer.

Before utilizing the locking feature of the Screw-Lock insert as an integral part of the WSI fasteners, Heli-Coil Corporation engineers conducted extensive bench tests on typical fastener installation for rigidity and resistance to vibration. Fasteners, located on three different planes of movement were placed on a vibration testing machine and subjected to vibrations of 10 to 40 cycles per second with amplitudes varying between ¼ and ½". No measurable signs of loosening in the "Heli-Coil" Screw-Lock threaded assembly were detected.

For more information on Heli-Coil (Screw-Lock):
Write No. 161 in Box on Inquiry Card
For more information on Western Sky Industries' Fasteners:
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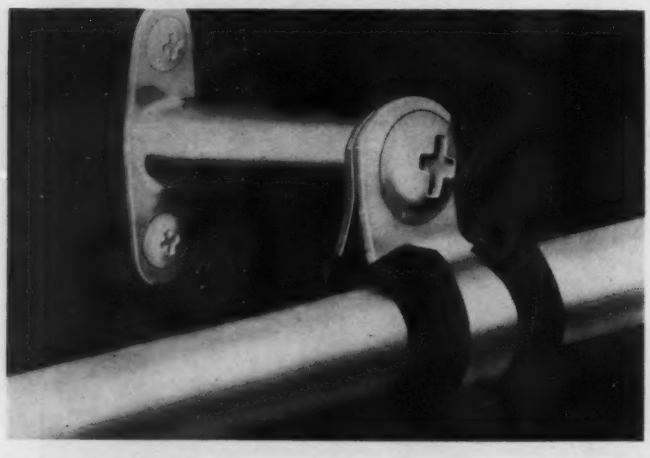

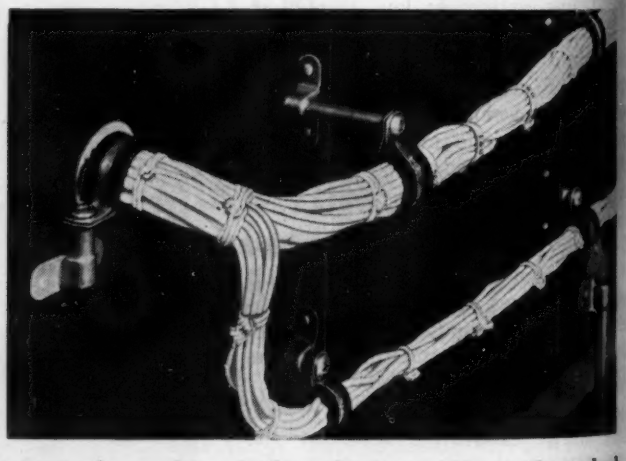

Fig. 3 WSI forged aluminum single and double fasteners are available in various lengths in increments of 0.1". Latest developments, increasingly used for right angle mounting in airframes, are the WSI-4 and WSI-5 fasteners. The new fasteners replace combinations of nut plates, tube spacers and attachment lugs and do not require a clearance hole that penetrates and weakens the structural member. This type is also used in missile packaging, with or without shock absorbers, to attach delicate equipment to mounting plates which in turn are attached to the packing case. These cases must withstand high impact loads. Photo at right shows use of forged stand-off fasteners. Currently WSI is developing a new extruded type which will combine the technical advantages of forged fasteners with lighter weight.

NYLON ADHESIVE

Nylon to Nylon Bonding With Only Contact Pressure

Nylon to nylon adhesive bonding within seconds is speeding the assembly of a newly designed Interrupter-Timer for automatic office telephone switchboard service. Produced by the Sessions Clock Company of Forrestville, Conn., for the A. W. Haydon Company, Waterbury, Conn., the timer performs twelve switching functions in unattended switchboards including activating flasher lights, bury tones, and bell signals.

For minimum noise and long-term service the timer gears, cams and cam followers were designed in nylon plastic. Due to the complex shape of the cam shaft and associated drive gear, this part was molded in two sections. Subsequent joining of these two parts on an assembly line basis, however, proved to be a problem.

After evaluating a number of assembly methods, Haydon's engineers found the use of Eastman 910 Adhesive to be an ideal solution. Easy to apply, the adhesive forms unusually strong nylon to nylon bonds within seconds. Although considerably more expensive than other commercial bonding agents, Eastman 910 Adhesive has proved to be economical in this application, with approximately 6,000 bonds being formed with one half pound of the adhesive.

Fig. 1 In assembling the nylon gear and associated cam, one drop of Eastman 910 Adhesive is placed on the end of the gear shaft with a stylus applicator. The end of the cam which is held in the upper jaws of the jig is brought into contact with the gear shaft and held for a few moments. A strong bond is formed in about 10 seconds.

The adhesive, available from Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, is the first bonding agent, according to the company, to produce quick-setting, high-strength bonds between virtually any combination of materials without the necessity of catalysts, heat, solvent-evaporation, or more than contact pressure.

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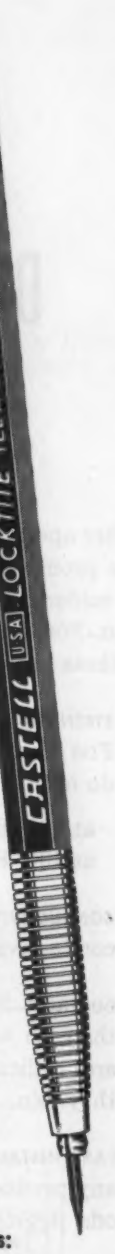
Aren't You Entitled to the Best?



If you were a doctor, you wouldn't use a cheap stethoscope. If you were a violinist, you wouldn't think of playing a concert on a scratchy fiddle.

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A.W.Faber Locktite 9800 is not a luxury. It is a necessity. It is the ultimate means by which you translate your creative skills. It is the bedrock of your ability, the criterion of your worth—the direct influence of your livelihood—and the index of your future success. In the light of these values, can you afford to use a less-than-best lead holder?

Only Locktite 9800 has all of these exclusive advantages:

- **Long tapered spiral metal grip that reduces finger fatigue.**
- **Gun-rifled clutch that grips the lead like a bulldog.**
- **TEL-A-GRADE indicator which instantly shows degree of lead in use.**

Plus perfect balance and featherweight lightness.

Try Locktite, buy Locktite 9800 today, the top quality lead holder backed by two centuries of experience.

FULLY GUARANTEED!

If it ever happens, that any part of a LOCKTITE Holder breaks in normal usage, the entire holder will be replaced free of charge.

#9030 Imported CASTELL Black Gold Refill Leads fit any standard holder. Perfectly mated with LOCKTITE. Sold by all good Dealers.

A.W.Faber-Castell Pencil Co., Inc., Newark 3, N. J.

CIRCLE NO. 24 ON INQUIRY CARD

HOW LOUIS ALLIS DOUBLED THE BENEFITS OF SIL-FOS BRAZING

Higher operating temperatures and output demands in electric motors have prompted Louis Allis of Milwaukee, Wisconsin, to switch from soft solder to SIL-FOS 5 brazing on their stator windings. No stranger to SIL-FOS, Louis Allis has brazed rotor end rings for years. Now they get these benefits on both vital parts of their motors:

STRENGTH—The strength of a properly designed and brazed SIL-FOS joint exceeds that of the metals joined. Furthermore, joints do not "creep" even when hot. Here are some typical values:

at 300° F in copper:	30,000 psi.	In brass:	35,000 psi.
at 400° F in copper:	28,000 psi.	In brass:	31,000 psi.

CONDUCTIVITY—Tightly fitted standard lap joints are fully as conductive as copper.

DUCTILITY—SIL-FOS joints have exceptional ductility; enabling them to withstand stresses and strains of vibration, shocks and radical temperature changes fully as well as the metals they join.

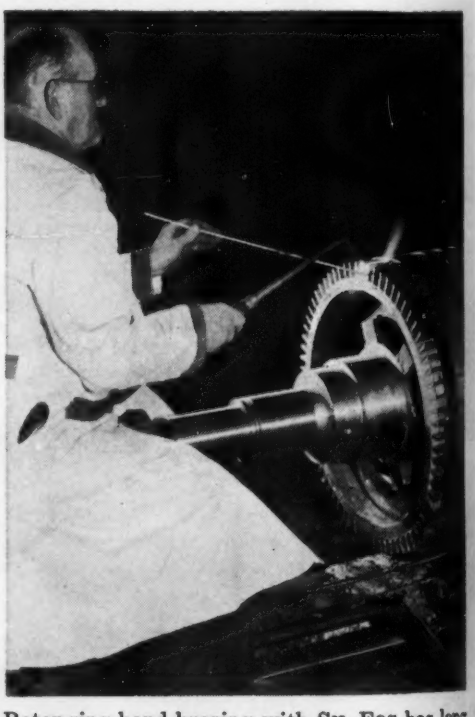
EASY INSTALLATION—FAST PRODUCTION—With SIL-FOS you can get any production you want—you have a choice of heating methods, jigging setups, inspection techniques, etc.

ECONOMY—Low flow point, fast brazing action, reduced labor costs, and vastly reduced reject rate, plus the small amount of alloy needed to make a joint put SIL-FOS in a low-cost category unequaled by other methods.

Alloy	Silver Content %	Type	Starts to flow at °F	Starts to flow at °C	Free Flowing at °F	Free Flowing at °C
SIL-FOS	15	Wide Melting Range	1185	641	1300	704
SIL-FOS 5	5		1195	646	1300	704

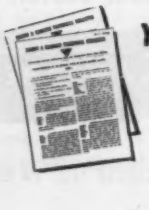
For use in joining ONLY nonferrous metals. Used particularly on copper, brass and bronze. Specially effective in joining pipe and tubing and on electrical work.

Here, operator hand brazes a winding on a motor stator. Increasing motor output requirements demand greater overall operational reliability. With SIL-FOS 5 brazed joints *reliability is assured.*



Rotor ring hand brazing with SIL-FOS has long been the practice at the Louis Allis Co. The success achieved here has been applied to the above with equally excellent results.

Further details on SIL-FOS and SIL-FOS 5 can be had in the form of Technical Literature from Handy & Harman. **Send for Bulletin 20.** Our research and engineering people are ready and willing to help you with any metal joining problem or plan you may have.



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CIRCLE NO. 26 ON INQUIRY CARD

DESIGN TIME SAVER

Phase in Lead, Lag Networks

By J. P. Cummings
Engineer, Ford Instrument Company
Long Island City 1, N. Y.

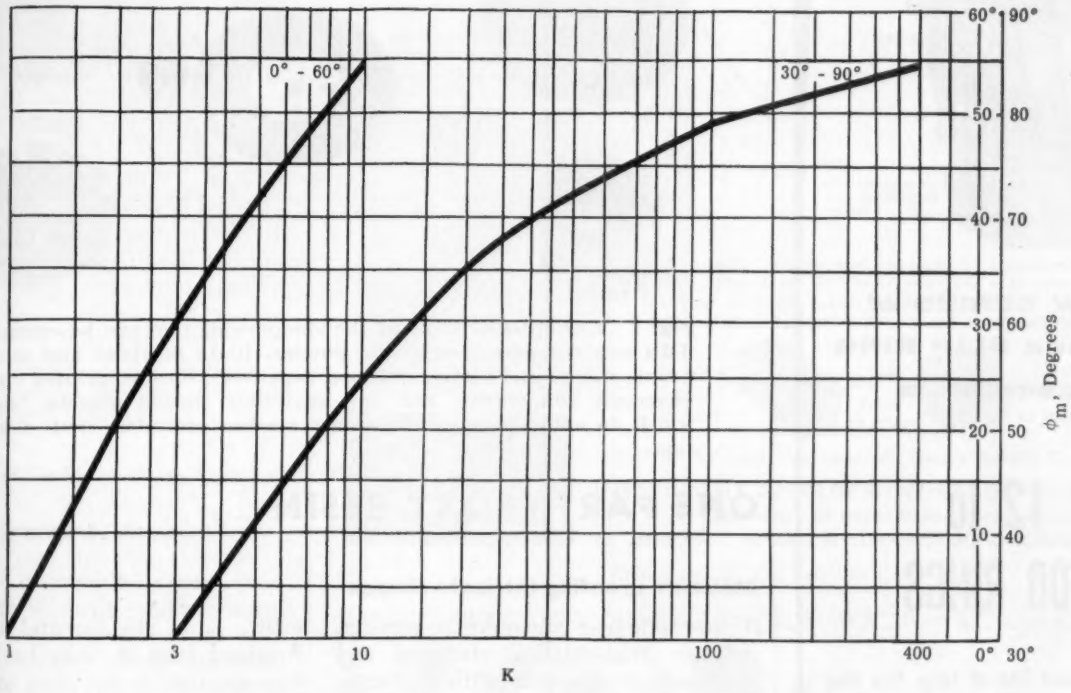


Fig. 1 Maximum lead or lag phase ϕ_m for a lead or lag interval K.

The design of a lead or a lag network for compensation is well known. However the equations are such that they first require a preliminary investigation of their phase—before any particular design can be done quickly.

Thus, for a lead or lag interval K, Fig. 1 gives the magnitude of its maximum lead or lag phase ϕ_m. This interval K equals ω_2/ω_1, where ω_2 is the upper breakpoint of either the lead or lag network. For other values of ϕ, Fig. 2 gives the ratio of ϕ/ϕ_m about its mean angular frequency which is $(\omega_1\omega_2)^{1/2}$.

These two figures allow a quick solution to lead, lag problems; e.g., say for the Bode plot of a particular uncompensated gain and phase network, a compensating lead network has its $\omega_1 = 1$, and the compensated gain has an $\omega = 2$ at the 0 db point. Now at this 0 db point, one requires say 57° of phase lead. To get the K for these values, initially let ω at the 0 db point equal $(1/2)$ $(\omega_1\omega_2)^{1/2}$. Then $\omega_2 = 16$, and $K = 16$, and $\phi_m = 62°$ from Fig. 1. To check this value of K use Fig. 2. Here ϕ/ϕ_m should be 92% (57°/62°) at $\omega = 2[\omega/\omega_1, (K)^{1/2} = 0.5]$. Once K is known, Fig. 2 is used to plot the compensated phase. For a compensating lag network, say from a particular Bode plot one requires a decrease of 40 db in gain or $\omega_2/\omega_1 = 100 = K$. From Fig. 1 this gives a $\phi_m = 78°$. Check to see if this would result in instability. Probably two phase lag networks are needed.

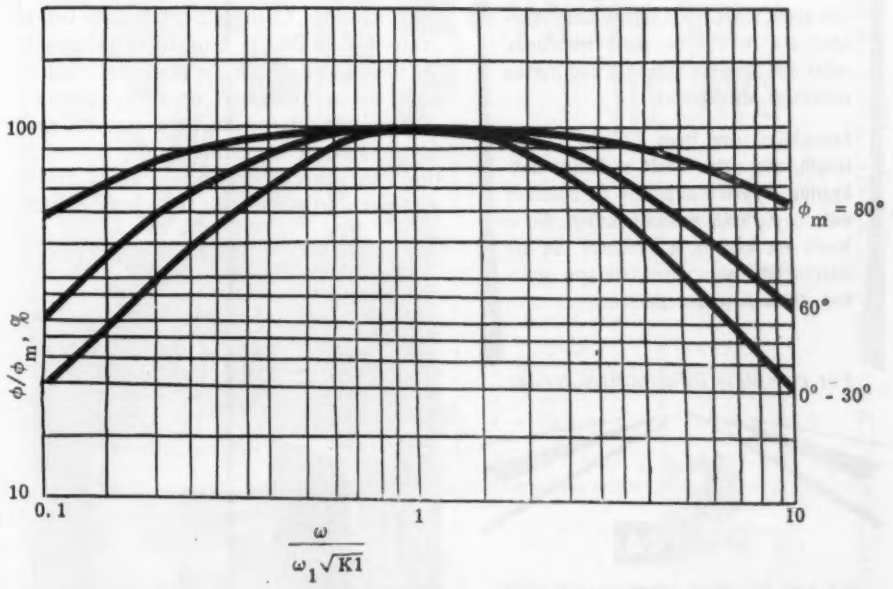
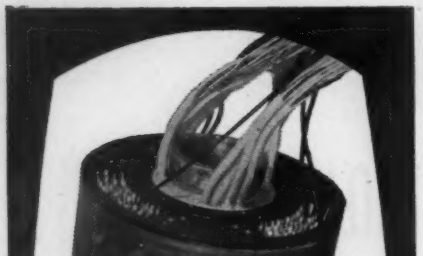


Fig. 2 The ratio of ϕ/ϕ_m.



NEW SERIES of Antenna SLIP RING Assemblies

12 to 500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

For complete information, write:

SLIP RING COMPANY of AMERICA

3612 West Jefferson Blvd., Los Angeles 16, Calif.

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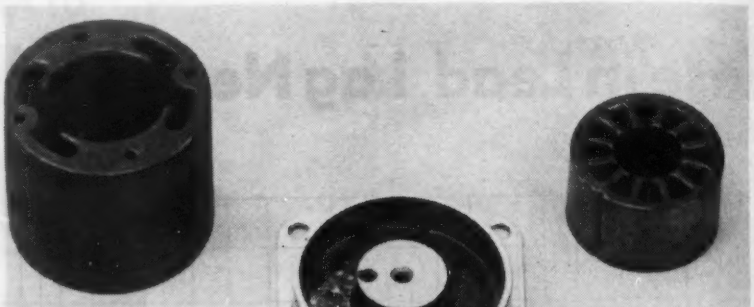


Fig. 1 Examples of some of the components that can be coated with 3M's new one-part epoxy resin powder. Resin insulates and moisture proofs stators and rotors, resistors, capacitors, toroids, printed circuits, electronic components and any intricately shaped objects. Surfaces which do not require insulation are masked with glass cloth electrical tape.

ONE PART EPOXY RESIN

Moisture proofing intricate shapes

A new one-part epoxy resin powder, for use in insulating electrical and electronic components with a tough, permanent finish, gives superior edge coverage and in most cases requires no post-cure. Called "Scotchcast" brand resin XR-5026, it can be applied by various methods of suspension coating, such as aerated bed or spray coating.

Application results in a smooth uniform coating by using a dip cycle of one to three seconds. The epoxy powder adheres to the hot object, melts, flows slightly and then cures. Retained heat in units having a high heat capacity is sufficient to completely cure the resin, eliminating the need for oven curing. The resin offers exceptional "cut-through" resistance in stator applications and a high degree of impact strength. In tests, an eight pound ball dropped from six feet on a .015 inch coating applied to a ⅛ inch steel plate did not crack the coating.

Developed by The Minnesota Mining and Mfg. Co., St. Paul, Minn., the resins electrical properties include an electric strength of 500 to 800 volts/mil.; a dielectric constant of 3.61 at 23 C and 60 cycles, and a dissipation factor of 0.0053 at 23 C and 60 cycles.

Fig. 2 Aerator test kit for suspension coating hot-dipped objects, includes four lbs. of resin and requires only attachment to low pressure air source for operation. Carton has tear-strip opener which creates base; fibreboard aerator can has a universal tapered inlet fitting on the air chamber. Aerator can be used repeatedly.

Write No. 150 in Box on Inquiry Card

Epoxy Casting Resin

A fire retardant epoxy casting resin which may be cured at room temperature has excellent adhesion to metals, plastics and ceramics. Due to the resin's low thermal coefficient of expansion and high heat stability, large embedments can be made. It is stable over a temperature range of −100 to +350°F. Emerson & Cuming, Inc., Canton, Mass.

Circle No. 505 on Inquiry Card

Hi Temp. Semiconductor Preforms

Silver-arsenic alloy preforms with a melting point of 1800 deg. F., is available for use in forming alloy junctions in silicon transistors in the precise shape of a sphere. The silver-arsenic preforms are 99% silver, 1% arsenic, and are in the .001 to $\frac{1}{8}$" diameter range, with diameters and sphericity held to ±.0001". The sphere will roll and lend itself to automatic loading into alloy jigs. Further, the sphere should offer the best possibilities for reproducible results since it represents the minimum oxidizable area per unit volume. Accurate Specialties Co., Inc., Woodside, N.Y.

Write No. 471 in Box on Inquiry Card

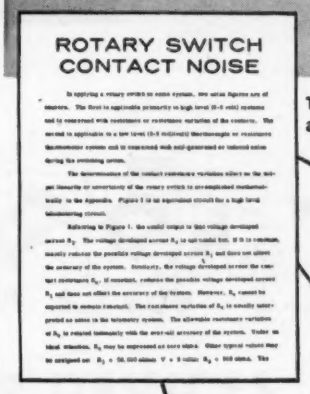
Ceramic Permanent Magnets

New isotropic ceramic permanent magnets have exceptionally uniform magnetic properties. They are made of a light weight, high energy material. High coercive force of the M-I magnets makes it possible to use much shorter lengths than with metallic magnets. It also offers unique magnetizing arrangements where both, or all poles, are on one surface. External fields or open circuit conditions do not have to be avoided, because the high intrinsic force of M-I ceramic magnets enables them to reproduce the original flux after being subjected to a strong demagnetizing influence. This permits magnetization prior to assembly and eliminates the need for keepering on disassembly. M-I magnets have an extremely high resistivity and can be situated in electrical circuits without producing a conducting path. In addition, this high resistivity virtually eliminates eddy current heating, should the magnet be placed in a high frequency field. Magnetic characteristics are: peak energy product (B_dH_d max), 1.0 x 10^6 gauss-oersteds; residual induction (B_r), 2200 gauss; coercive force (H_c), 1800 oersteds; resistivity at 25C, 1.0 x 10^6 ohms per cm^3; magnetizing field for saturation, 10,000 oersteds; reversible permeability, 1.2; Curie temperature, approximately 450C. Allen-Bradley Co., Milwaukee, Wisconsin.

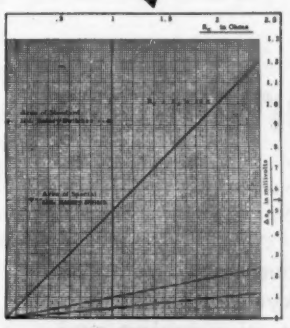
Write No. 461 in Box on Inquiry Card

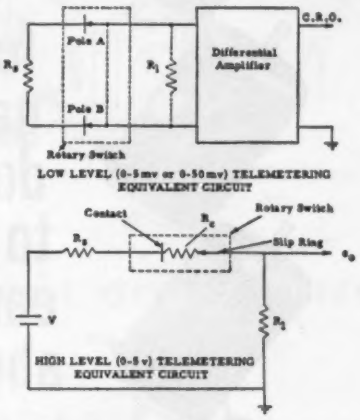
How Do YOU Define Switch Noise?

Here's how IDL analyzes it!



These data are important considerations in switch applications and provide you with valuable criteria for systems evaluation.





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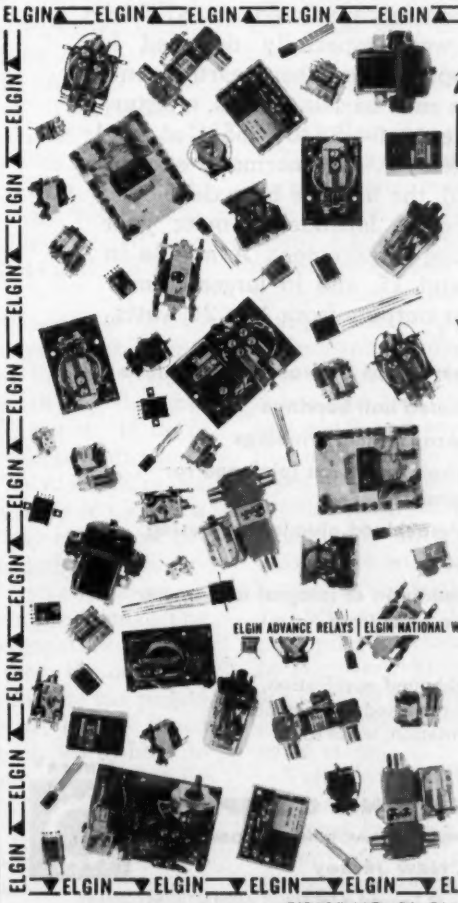

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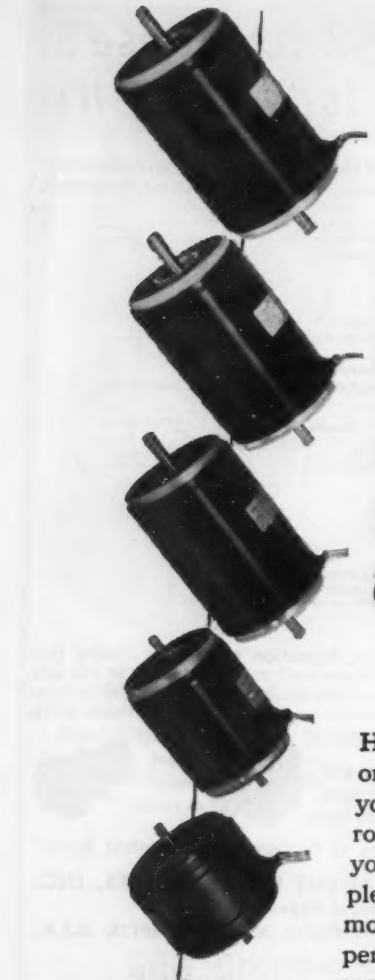

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CIRCLE NO. 30 ON INQUIRY CARD

MATERIALS

Mica Insulation

Dielectric strength of 1400 vpm characterizes General Electric's laminate insulation that consists of silicone-bonded mica mat sandwiched between layers of silicone-varnished glass cloth. Designed for both Class F and H applications, its expected uses are slot insulation for random-wound a-c armature coils, phase insulation in a-c motors and layer insulation in transformers. According to G.E. engineers, the composite's improved flexibility and snap-back characteristics result in greater conformity in wrapping transformer coils and insulating motor coil slots. Cut-through resistance is 16,000 psi at 200 degrees F. General Electric, Schenectady, N. Y.

Write No. 497 in Box on Inquiry Card

Transparent Sealing Glass

Visual inspection of the seal is possible by using a sintered glass, called clearform, glass-to-metal sealing. Clearform is made by pressing small glass particles to shape and then firing the piece at high temperature. Particles are consolidated by fusion into a nonporous, vacuum-tight structure. The composition is produced in a variety of shapes and sizes with extremely close tolerances and it retains the thermal endurance, corrosion resistance and dielectric strength of the parent glass. Corning Glass Works, Corning, N. Y.

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Class B Insulation

Consisting of a base fabric woven from polyester warp yarns and continuous filament glass filler yarns, a flexible insulation called Teraglas possesses high dielectric strength properties under elongation. In view of the high dielectric strength, thin sections or few layers may be used to provide the voltage breakdown protection desired. Natvar Corp., Woodbridge, N. J.

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High Temperature Potting Compounds

High temperature (5000°F) potting compound No. 0308 containing boron-free "Durock", has the following useful life: continuous at 4000°F, 5000 hours at 4500°F, one hour at 5000°F. Nos. 0307 and 0306 potting compounds, with maximum temperature ranges of 3000°F and 2000°F, respectively, are also available for electronic hardware use. Technical Industries Corp., Pasadena, California.

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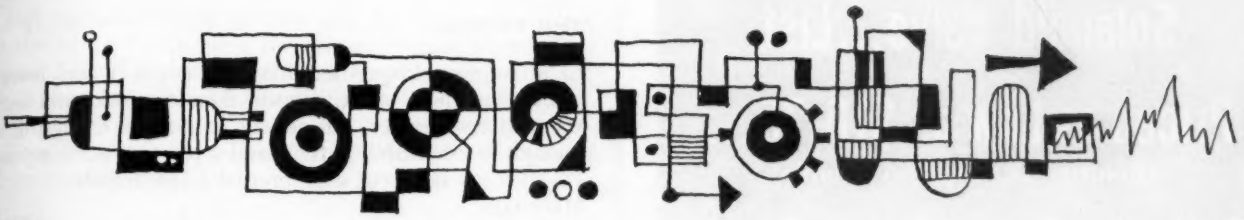

SEMICONDUCTOR DEVICES, present and future

Dr. Harper Q. North, *President, Pacific Conductors, Inc.*

Harper Q. North founded Pacific Semiconductors Inc. in 1954. He holds a B.S. from C.I.T. and an M.A. and PhD. from U.C.L.A. Because of Dr. North's contributions to and position in the semiconductor industry, we are presenting his analysis of the various electronic devices that figure prominently in today's state of the art; these comments were taken from material he presented to an IRE meeting held in Seattle, Washington last May 24th.

The field of semiconductor devices is developing so dynamically that most of us in it are wondering what's coming next, and those of us in industry are trying to outguess our competitors and are placing rather substantial bets on specific devices hoping that we are right.

In connection with this business I can't help recalling a recent story about a dinner attended by President Eisenhower and Dr. Vannevar Bush, former head of the Office of Scientific Research and Development. Another guest asked Dr. Bush, "What's new in science?" The President commented, "How would he know; he's out of touch; he's been here for over an hour.' The analogy with semiconductors is close. By the time this symposium is over, my speech may require serious revision. In any event, my only claim to fame as a prophet or as a croupier in this educated dice game is that I have been a player since 1941 and still seem to be participating.

Someone has said, "Today's premium device is tomorrow's reject." This, in a nutshell, is a synopsis of the semiconductor business. A manufacturer must look far enough ahead to see what will be needed in quantity by the time he has achieved the capability of producing it. If he is not far-seeing enough, competition is already dropping prices by the time he starts selling. If he is ahead of his time, he builds up inventories for which there is not yet a market and he becomes discouraged (to say nothing of becoming poor) until his devices have been designed into circuits and tested and re-tested. Then the systems into which they have been designed must be placed in production. The device manufacturer can copy what his competitors are doing and count upon fighting for position from the outset, or he can be smart and ingenious and hope that he has picked the winner—and what is all important—that he has timed his development properly. It's a terrible choice to have to make between copying and expecting an immediate fight and being ingenious with the possibility of being out of phase. It's a choice which calls for all of the wisdom which a manufacturer can muster and for careful extrapolation from the past through the present to the uncertain future.

PRESENT SEMICONDUCTOR DEVICES

Today's picture of the semiconductor device industry and its technology stems from a beginning really not much earlier than in the mid-1940's. The germanium point contact diode of 1945 has evolved through the gold bonded unit to the alloy and diffused junction diodes and rectifiers handling several hundred milliamps. Large germanium power rectifiers, handling heavy currents at high efficiency, are now powering aluminum processing plants or can do so when called upon.

The silicon radar mixer crystal of 1941 has progressed as far as germanium or farther in a comparable period of time. The war-time mixer crystal has evolved into today's parametric amplifier as a mixer and into the hundred ampere power rectifiers in wide-spread use. Banks of these rectifiers power locomotives in Europe and are being studied for that purpose in Asia.

Germanium alloy transistors are being mass-produced here at low cost (and obviously in Japan) for transistor radios and soon will find their way into transistorized TV sets which will enjoy wide distribution. Frequencies in the thousand megacycle range are possible in more advanced types of germanium units if high power is not required.

Silicon transistors are gaining momentum rapidly, particularly in switching applications where high-speed requirements were expected to limit their usefulness. High frequency and high power units have made their appearance and fifty watts at five to ten megacycles is already available from pilot line transistors, which are being eagerly sampled by engineers. Moreover, units have been constructed which are capable of delivering up to fifteen hundred watts without appreciable frequency degradation below the ten megacycle range.

Variable capacitor diodes have furnished a tuning element and the race toward solid-state circuitry has started. Powered by solar cells or thermoelectric generators, these circuits leave only inductances as a stumbling block, and progress on solid-state inductances is being reported.

New 3-Way Nylon-Body Solenoid Valve...List Priced as Low as $10.75...

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Write today for complete technical data on this shock-resistant, pressure-proof valve—the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

5374 Carnegie Avenue, Kenilworth, New Jersey

CIRCLE NO. 31 ON INQUIRY CARD

THE FUTURE

In attempting to predict things to come, I feel more like a familiar radio commentator than an industrial man or scientist or engineer, but as long as I avoid doing this often enough to establish a pattern and a per cent accuracy rating, I'll stick my neck out and forecast a few trends.

Materials:

The silicon versus germanium trend is becoming clearer. I predict that ultimately 80 to 90% of all germanium semiconductor devices will be replaced by those employing silicon as an active element.

The advantages of silicon are predominant over those of germanium in all but a few applications. The higher mobility of germanium is a factor at microwave frequencies and its lower forward voltage drop is desirable in applications requiring extremely low resistance switches.

However, the oxide of silicon has wonderful properties for the device manufacturer to work with as compared with that of germanium, which has two crystalline forms, both of which are soluble and somewhat porous. As a consequence, the diffusion process which has become so important is better suited to silicon than to germanium. The impervious oxide formed on silicon makes an excellent mask in the process of diffusing-in impurities in complicated geometrical patterns. In addition, the silicon device, because of its oxide coated element, promises greater stability and reliability than can be achieved readily with germanium. Silicon devices surpass those of germanium in high temperature performance, operating satisfactorily at 175 to 200C as compared with the 90C limit for germanium.

Finally, silicon devices should be cheaper than germanium devices in the long run. This is not likely to be the case until technologies are equally advanced and until automation reduces the labor content appreciably, but 20% of the earth's crust is silicon, and processing of transistor grade silicon should become less costly as consumption increases. Germanium, on the other hand, is a relatively rare element estimated to be present as only about 1 part in 10^{13} parts of the earth's crust. Supply and demand, I think, will inevitably raise the cost of germanium unless new sources are found and will lower the cost of transistor grade silicon. Until now, silicon devices have enjoyed premium prices because of their performance and have suffered from higher production costs than germanium units only because germanium technology was acquired prior to that for silicon. Germanium will probably disappear slowly in the semiconductor business, however, because of its momentum and the difficulty of replacing devices with those of different characteristics; nevertheless, I'm counting on the ultimate displacement of germanium by silicon in the years to come.

Intermetallic compounds are receiving a lot of attention these days, but the technology for handling them presents a deterrent even greater than that which silicon encountered during its formative years. Today's intermetallic compounds are good enough (and actually the best material known) for devices which require heavily doped semiconductors and in which crystalline dislocations are less important. The Esaki or tunnel diode is an excellent example of a device in which chemical purity and crystal perfection do not seem to be vital factors. In this example, gallium arsenide has proved to be a useful material. The compounds may remain hard to handle for some time and may actually be expensive in the long run (in the case of gallium arsenide,

the cost and scarcity of gallium may be a deterrent) but they should evolve in time for use in devices where high temperature and high frequency performance are important limiting factors. Gallium arsenide's electron mobility of 4,000, for instance, removes the frequency limitations experienced by silicon whose electron mobility of 1,800 stands at approximately one-half that of germanium.

DEVICES

These days, there is considerable discussion concerning the future of a list of devices which are receiving widespread publicity. Varactor diodes were the rage not long ago in the technical press, and in my opinion they are far from being placed on the shelf. They are on the way toward eliminating other forms of mixing devices. The requirement of pumping power is a drawback, but as the saying goes, "You can't have everything." They undoubtedly have a future also in the multiplication of frequencies at high powers. Through their use, as much as three quarters of a watt of power at one thousand megacycles has recently been achieved. Moreover, the varacator diode should serve as an excellent duplexer in circuits where the capacitance of the diode can be tolerated.

The Esaki or tunnel diode is a remarkable device. Its use as an ultra-high frequency oscillator of modest power seems assured. Its employment as a switch is more in doubt. I'm not a circuit man, but it seems to me that the bloom has faded just a bit in recent months on this device as a switch. A third control electrode may be needed. We don't have one yet. If we can get one, I'll reconsider, but guessing today, I'll look for several years toward other devices for the purpose of switching.

From the standpoint of frequency limits in transistor circuitry, I'd say that our back is almost to the wall. The germanium transistors which have reached twenty-five hundred megacycles or higher have emitter and base stripes one mil by three tenths mils in size. This is beginning to split hairs, in my estimation. There must be a better way to go higher in frequency. Bulk phenomena of the type employed in the maser seem to me to offer a better course.

Performance at high power is another matter, even at ultra-high frequencies. I mentioned a fifteen hundred watt transistor at five to ten megacycles. This can undoubtedly go into the five kilowatt range without serious frequency degradation if we can learn to use extremely low impedance devices, but there is another limitation. Once more, it stems from semiconductor technology limits. The same phenomena that reduce yield in small units appear in spades when a bad spot on a one inch square transistor surface completely destroys device performance. But the high power transistor seems to be here to stay, and perhaps as a high speed switch as well as a high frequency oscillator and amplifier.

The controlled rectifier, these days, is rising in prominence. I'd say that it has a bright future. There are thousands of places where high variable inductances or thyratrons can be replaced. If controlled rectifiers are as cheap as I am sure they will be, there will be new uses even in such prosaic applications as dimmers for home lighting.

I have reserved until last my comments on the controversial solid-state circuit because it receives both honorable and dishonorable mention. The solid-state circuit comprises an assembly of devices—diodes, transistors, resistors, and voltage variable capacitors—all formed within a single block of semiconductor material, preferably silicon (at least for

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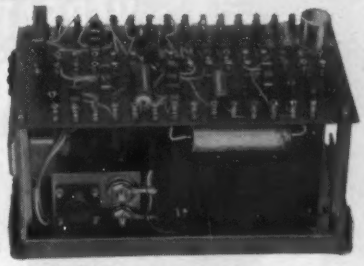

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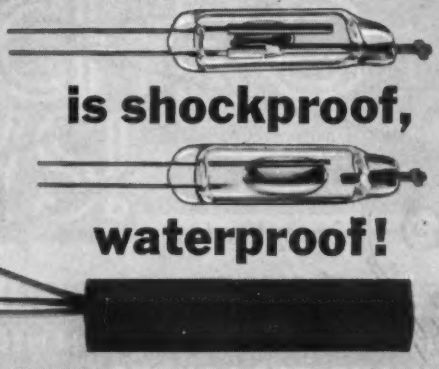

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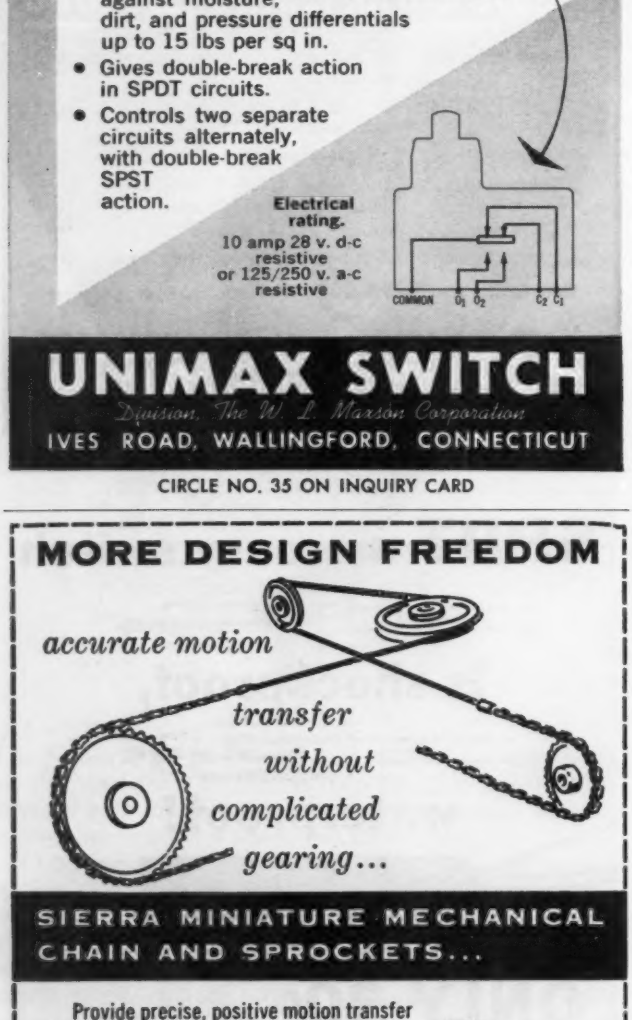
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the present). There is no doubt whatever in my mind that such circuits will one day be in widespread use. The only question is when. Here, semiconductor technology is a seriously limiting factor. It is not quite true, but almost that the yield of good circuits is the product of the yields of the individual components comprising those circuits. If the yield of a sophistcated individual component is, say, 50%, that of circuits with four components is $(.5)^4$ or about 6%. I worry about the economics of producing circuits to this kind of yield, except where size is of ultimate importance as perhaps in satellites where the market, to say the least, is rather small. Isn't it better at this stage of limited technology to weld together micro-components, each of which has been proved through prolonged life tests and in thousands of circuits? Reliability has been touted as a compelling reason for solid-state circuits. Perhaps if we know how to protect such circuits well, this is an achievable virtue. We are getting there and can do it, but the yield is modest even on individual components.

For what it's worth, my opinion is that desire is ahead of technology in solid-state circuits and that we'd better set about improving technology before talking about the wild blue yonder of "molecular circuits" where each molecule is in the right place with an error well below one in a thousand. I am sure that publicity is well ahead of technology. It's a somewhat easier field, and much less expensive to pursue. In my opinion, a manufacturer of micro-components has several years to enjoy a market for his products before he is superseded by solid-state circuits, to say nothing of molecular circuits. Solid-state circuits are on their way and work on them is well advised. Five to ten years from now, I'd guess, they'll be in mass production. By then, they'll begin to take over, and when they do, we'll see a brand new kind of computer with redundant components like those in the human brain. In the meantime, I'll bet on the advisability of learning control, advancing technology, and using a lot of micro-components, each tested for performance before assembly to avoid devastatingly low circuit yields and correspondingly high costs.

CONCLUSIONS

It's impossible to cover the maze of exciting devices before us, particularly in twenty minutes. I've chosen the controversial ones; the varactor diode, which I think is with us from now on in mixing, frequency multiplication, and duplexing; the Esaki or tunnel diode, a remarkable device for microwave oscillators and for use in computers, particularly if a third electrode can be added. I'm guessing that transistors as such are reaching their frequency limit because of the geometries required to push that limit. Power levels at ultra-high frequencies will be even higher with certain difficulties, such as very low impedence standing in the way, difficulties which we'll have to learn to handle. Maybe we'll learn from the Esaki diode, which has encountered similar difficulties. The controlled rectifier is here. Its use will grow rapidly as cost is reduced.

To solid-state circuitry goes my deepest sympathy. It's a wonderful concept degraded by over-publicity and about to experience retardation, I think, as a result of over-optimism. But when technology catches up with it, we'll be able to strive toward brain-like circuitry with a vengeance. I'm guessing it will take five years or more. By then, semiconductor devices will be full circuits and will really come into their own. Meanwhile, a lot of laboratories will work on them, but some of us will depend upon the sale of microdiodes and transistors to fill the gap and to foot the bill.

WORTH FILING

Sub-Miniature Terminals

18 page catalog on Teflon insulated stand offs, feed thrus, jacks and plugs includes technical data such as voltage and capacitance ratings. Greater holding power between chassis and terminal is attained by high density, low void content Teflon material processed by special techniques.

Source: Tri-Point Plastics, Inc., Albertson, N.Y.

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Pressure Hose

24 page technical bulletin describes a pressure hose, called Hytron, for hydraulic and other high pressure applications. The hose consists of a seamless extruded inner tube of special virgin polyamide material, a high tensile strength polyester reinforcement and a cover of extruded polyamide formulation. Bulletin explains how Hytron differs from rubber hose, the limitations of Hytron hose, comparison of flow area between standard and Hytron couplings and other engineering data.

Source: Imperial Brass Mfg., Co., Chicago, Ill.

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Inertial Guidance Test Equipment

24-page brochure combines specifications and photos on precision turntables, rate tables, air bearing and fluid bearing tables, electronic test equipment and consoles and related products.

Source: Sterling Precision Corp. Port Washington, N.Y.

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Function Generators

Catalog contains complete design information, applications and operation of ac potentiometers and adjustable function generators. The Vernistat ac potentiometers combine a precision, interpolating potentiometer with a multi-tapped autotransformer, and relates multiturn mechanical shaft rotation to voltage. The Vernistat adjustable function generator provides a means for generating nonlinear functions with accuracy and rapid adjustability.

Source: Perkin-Elmer Corp., Norwalk, Conn.

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Facts on Patents

"Preparing for Patent-hood" tells what to do with your invention idea; when to talk with a patent attorney; importance of dates and a verifier; facts about the patent office; application handling; revising claims; claims and patents; economic importance of patents; and foreign patents.

Source: Trak Electronics Co., Wilton, Conn.

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Semiconductor Directory

Purchasing directory includes power, high speed switching, high-current, zener and diffused junction mesa type transistors. It also lists micro-diodes, voltage-variable capacitors and photosensitive devices. This 16-page directory and buyer's pricing guide to transistors, diodes and rectifiers covers semiconductors of 18 major American manufacturers.

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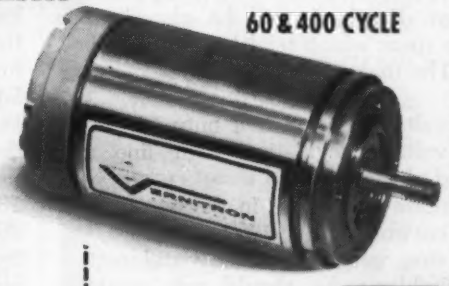

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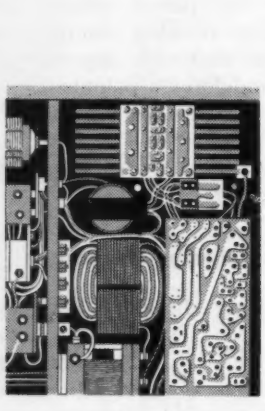

REGULATED DC POWER SUPPLIES

By: MARTIN GLASBERG, *Contributing Editor*

Regulated dc power supplies are relatively simple devices from the user's standpoint, although they can be extremely complex for their designer. The user of a power supply generally wants a constant dc voltage independent of time, line voltage, and load impedance. The designer offers him a variety of supplies which approach the ideal in some areas but not in others.

In discussing regulated supplies from the user's point of view, we will consider the supply as a "black box" and discuss performance criteria. Our objective will be to look at the different kinds of supplies and see how they compare on the basis of their specifications. Emphasis will be placed upon the specs which tend to be overlooked.

The user is sure to know

- voltage and current output.
- voltage regulation with line and load changes.
- noise and ripple in the output.
- environment.
- size, weight, reliability and cost.

Problems he should not overlook, especially if he is working with transistors are

- turn-off and-on transients.
- dynamic regulation: recovery time and maximum excursion for sharp load or line changes.
- ac output impedance.
- overload protection and "fail safe" features.
- stability ability of the supply to hold the same dc output over extremely long periods of time.

OPEN LOOP REGULATION

In an elementary form a regulated dc supply consists of a power transformer, some rectifiers, a filter, and a VR (voltage regulator) tube. The first three elements convert the line voltage to a predetermined dc voltage and the VR tube holds the voltage constant. The VR tube is simply a gas discharge tube, similar to a neon bulb, which tends to keep its voltage drop constant. Consequently, if the VR tube is across the output, it will shunt current into the load until the load voltage is equal to the constant VR drop. The worse case for the VR tube, or any shunt regulator, is when the load is disconnected and maximum current flows through the regulating device.

VR tubes are designed for around 100 volts and can conduct a maximum of about 50 milliamps. They will hold their voltage within about 2% for current changes of about 4:1. Regulated supplies using regulator tubes are, therefore, limited to rather high voltages and relatively low power. Note also that the output of these supplies must be constant at the VR tube voltage, or voltages when a string of tubes is used.

Zener diodes have characteristics similar to those of the VR tube and are used in the same way. Zener voltages can be obtained from 3 to 200 volts with maximum dissipation reaching about 50 watts. The shunt regulation with a zener is about 1 or 2% for current changes of about 10:1.

CLOSED LOOP REGULATION

Both the zener diode and the VR tube will hold their voltage very accurately if they conduct a constant current. This characteristic points toward using the zener and the VR tube as references instead of control devices. In this case the dc output voltage is compared with the reference. The difference is then fed to a control device which corrects the output voltage until it is approximately equal to the reference. This procedure, of course, is feedback control, and is used in most of the regulated supplies today.

A dc supply using feedback control is subject to all the frailties of feedback systems: accuracy proportional to loop gain and stability inversely proportional to gain. On the whole, however, using the zener diode or the VR tube as a reference element increases regulating ability and power handling capability tremendously.

TYPES OF SUPPLIES

So far we have mentioned only the elements used as a reference in the feedback control dc regulator. Basically

TABLE 1

Check List For Regulated DC Power Supplies

1 Output Voltage - Range of voltage over which supply can be controlled.

2 Output Current - Range of output current available.

3 Steady State Regulation - Percent change in output voltage for a slow change of ±10% in line voltage and or a slow change in load from no load to full load.

4 Ripple - Harmonics in the output which are related to the line frequency. Measured either as an rms magnitude, as a peak to peak voltage, or as a percent of the ratio of the rms magnitude and the output voltage.

5 Dynamic Regulation - The ability of the supply to regulate sharp changes in the load and or line. Measured by the maximum excursion of the output voltage for a step change in load or line. Also measured by the time it takes to recover to within its steady state regulation limits, called recovery time. Dynamic response can also be measured by the time required to recover 63.3% of the maximum excursion, called the response time.

6 Off-On Transient - The peak output overshoot when the supply is turned off or on.

7 Output impedance - The ratio of the change in output voltage for a change in output current. Slow changes will produce the dc output impedance, fast changes will produce the ac.

8 Stability - Ability of the supply to hold a constant voltage for an extremely long period.

9 Overload Protection and "Fail Safe" Features - "Fail Safe" features refer to the ability of the supply to protect the load against voltage peaks even while it is failing. Overload protection refers to the supply's ability to protect itself from excessive power demands.

10 Environment - Temperature range, shock, dust, etc.

11 Size, weight, type of construction, cost, etc.

there are three other types of elements used: vacuum tubes, transistors, or mag. amps. These other elements are required to perform two functions; first amplifying the error signal and second controlling the output voltage. Different combinations of the above three elements are used to perform these two functions.

The most popular types of dc feedback regulators are:

- Magamp—This type uses only magnetic circuits. It is extremely rugged but relatively slow in responding to sharp changes.
- Vacuum Tube—This type of supply uses vacuum tube circuits, generally a VR tube. It has fast, dynamic response and will withstand high voltages, but is less rugged than transistor or magamp. supplies.
- Transistor—An all transistor supply, usually using a zener diode, is quite small and rugged, has fast dynamic response, but is temperature limited.
- Transistor – Magamp or Vacuum Tube–Magamp–have either transistor or vacuum tube amplifiers and magamp output controllers. The characteristics of these supplies, as would be expected, are between those of the all transistor or vacuum tube and the all magamp supplies.
- Magamp–Transistor–this type uses the magamp to regulate line variations roughly while the transistor feedback control operates as usual.

SPECIFICATIONS

With the above as a background, the best approach to the discussion of power supplies is to consider the check points of Table I.

1. Voltage Range–Transistor and magamp–transistor supplies, at present, have high voltage limitations; their voltages range from 0 to about 75 volts. All the supplies with magamp outputs and the vacuum tube supplies can be found in the 1000 volt and up range.

2. Current output–The transistor output supplies will generally range up to 30 or 50 amps, with the vacuum tube supplies in the 2 amp range, and the magamp output supplies at extremely high levels.

3. Steady State Regulation – Steady state regulation refers to percent changes in the output voltage for slow changes in the line voltage and output impedance. The test is generally a slow change of ±10% of the normal line voltage and a slow change from no load, or 10% of full load, to full load. The magamp supplies hold the output within about 1% for the line changes and within about 1% to 10% for load changes. The transistor-magamp or vacuum tube-magamp supplies hold the output within about 0.25 to 0.50% for the load and line changes. The transistor or vacuum tube supplies will hold the output within about 0.25 to 0.05% for the slow load and line variations.

4. Ripple–The ripple refers to the harmonics of the output voltage which are related to the line frequency. The ripple is generally measured in percent rms which means the percentage ratio of the rms value of the ripple component to the output voltage. Ripple is pretty much proportional to the regulation and varies from about 1% for magamp output supplies.

5. Dynamic Regulation–This specification is especially important in supplies used to power transistor circuits because sharp line or load transients can cause voltage peaks in the output and breakdown in the transistor load. A very good comparison of the dynamic regulation of the various types of sup-

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Input Impedance (ohms resistive)/ 100,000
Voltage Gain (Resolver compensating winding output to input)/1 ±0.02
Phase Shift (Rotor output to input)/ Less than 15 minutes
Max. Signal Output Voltage/16 volts
Signal Frequency (cps)/400 ±20
Power Input at 10 MA Max./40 VDC ± 1 V
Maximum Input Voltage (Volts RMS) /60
Voltage Transfer Ratio/1 ±.0005

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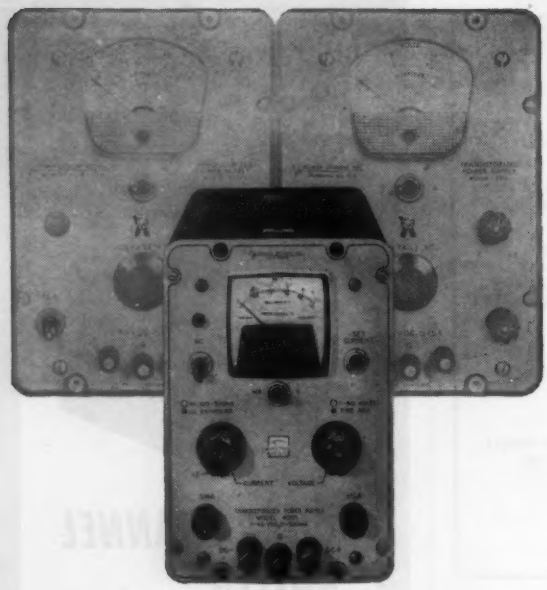

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COMPONENTS DIGEST

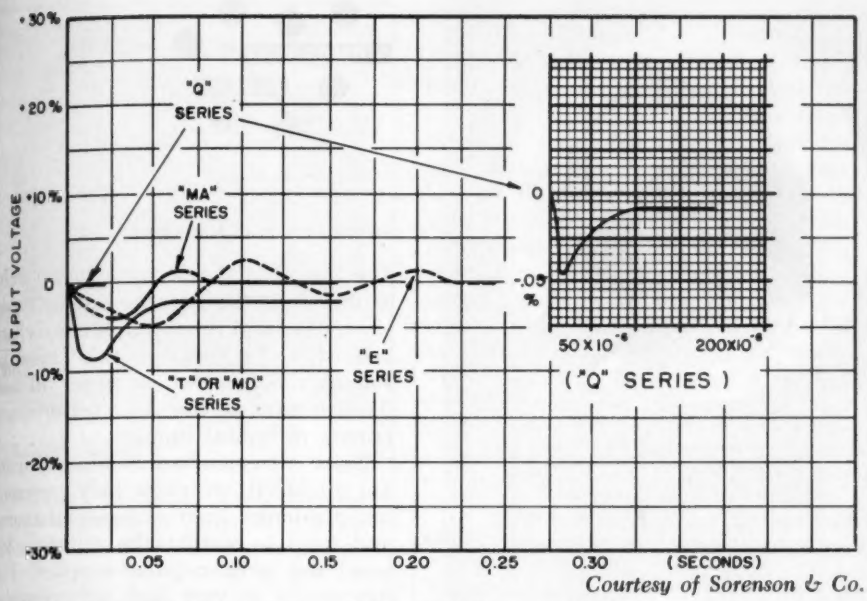
plies is shown in Fig. 1; four curves show the response to a 20% change in load.

There are two ways to measure dynamic response. The first is recovery time: the time required for the output to recover from a transient to within its regulation limits. The second, and most popular, is response time: the time required by the output to recover 63.3% of the maximum excursion of the transient. Transistor output and vacuum tube supplies have a response time of between 50 and 100 microseconds for the sharp load variations, and essentially zero transient for the line variation. The transistor or vacuum tube-magamp supplies have a response time of between 0.1 and 0.3 seconds and pass line transients with almost no attenuation. The all magamp units have a response time of about 0.1 seconds, with an 8% maximum excursion of the output for a 20% load change. The magamp supply, however, will generally hold the sharp line variations within steady state regulation limits.

6. Off-On Transients – Peaks in the output voltage can occur quite easily when the supply is switched off or on. Generally, transistor supplies, since they have no warm-up time and fast dynamic response, will have the same transient behavior when being switched as while running. Vacuum tube and magamp supplies can have trouble with off-on transients. Example in Fig. 2 compares off-on transients in a magamp supply and a magamp-transistor supply.

7. Output Impedance – Output impedence is the ratio of the change in output voltage for a change in output current. If these changes are very slow, the output impedance is called the dc impedance. It's quite evident that the steady state and dynamic regulation performance determine, respectively, the dc and ac impedance. DC output impedance is commonly considered, but the ac impedance and its counterpart, the dynamic response, are often neglected. The ac impedance, however, can be very important in supplying power for switching circuits or high frequency amplifiers.

There are a number of procedures for measuring ac impedance, but the usefulness of the results depends upon the type of load variation encountered. Referring back to the discussion of dynamic regulation, we can



Courtesy of Sorenson & Co.

Fig. 1 Output voltage after a 20% step change in load. "Q" series refers to transistor supplies (same response for vacuum tube supplies); "E" series refers to vacuum tube-magamp units; "MA" series refers to transistor-magamp supplies; "T" or "MD" refers to pure magamp supplies.

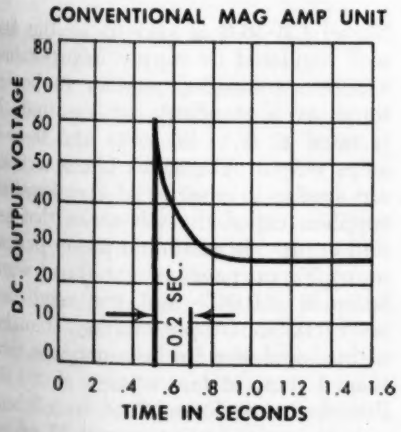
say that various types of supplies have, roughly, ac output impedances proportional to their response times. The exact ac impedance curve will vary quite a bit with frequency depending upon the characteristics of the actual feedback control loop.

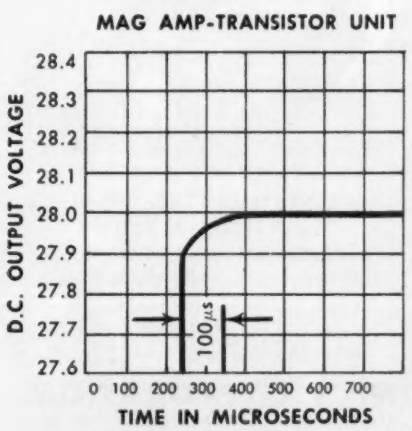
8. Stability and Reliability—Transistor and magamps supplies are generally considered more rugged than vacuum tube supplies. Reliability has also been equated to complexity; on this basis the magamp would definitely lead. Another criterion of reliability is based on the supply working within wider tolerances, even after certain components have failed.

The stability refers to the supply's ability to hold its output voltage constant for an extremely long time, approaching the lifetime of the components. In general, stability depends more upon the reference than anything else because of the inherent stability of a feedback control system. Battery references are very precise but tend to age badly. Zener diodes have good aging characteristics, but are temperature sensitive. VR are sensitive to light, rf interference and temperature, although to a relatively small degree.

9. Overload Protection and "Fail Safe" Features—The supply should be protected from burning out from varying amounts of continuous overloads. The best type of protection is to reduce output voltage when the output current exceeds its ratings. An indication of the decrease in voltage should be given. To protect a transistor load when and if the supply fails, no large output voltage peaks should be produced by the failure of any element in the supply.

10. Environment — Temperature range is the only environmental problem easily discussed and only to the extent of mentioning the temperature limits. For most supplies this limit is an ambient of 40-50 C.





Courtesy of Perkin Engrg. Corp.

Fig. 2 Typical "turn on" transient "overshoot".

BASIC BUILDING BLOCKS FROM KEARFOTT

SIZE 11 MOTOR GENERATOR

Featuring 300:1 Signal-to-Noise Ratio

The high performance Size 11 Servo Motor Generator features 0° phase shift and a signal-to-noise ratio of 300:1. It is designed primarily to replace Size 15 units in high gain damping applications. In-phase speed-sensitive output variations due to temperature variations are stabilized to within 0.2%/°C over the temperature range and speed-sensitive voltage and frequency variation are stabilized to within ±0.2% for voltage and 0.03%/cycle for frequency.

ELECTRICAL CHARACTERISTICS

MOTOR	Fixed Phase	Control Series	Phase Paralle
Voltage (volts)	115	36	18
Frequency (cps)	400	400	400
Current (ma)	53	155	310
Power Input (watts)	3.5	3.5	3.5

GENERATOR		
Excitation	115 volts	400 cps
Volts Out at 1000 RPM	2.9V	
Phase Shift at 2600 RPM	0°	
Null Fundamental RMS	5MV	
	10MV	
Linearity 0-3600 RPM	0.2%	

MECHANICAL CHARACTERISTICS

No Load Speed	5500 RPM
Stall Torque	0.55 Oz. In.
Rotor Moment of Inertia	7.7 gm cm²
Theoretical Acceleration	12,800 rad/sec²
Weight	9 oz.

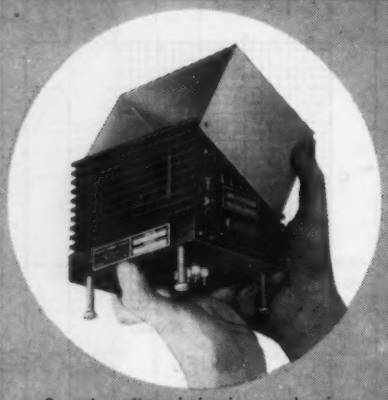
Write for complete data.

KEARFOTT DIVISION GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 39 ON INQUIRY CARD

WHAT THIS UNUSUAL AC-DC "PLUG-IN" TRANSISTORIZED POWER SUPPLY DESIGN GIVES YOU...



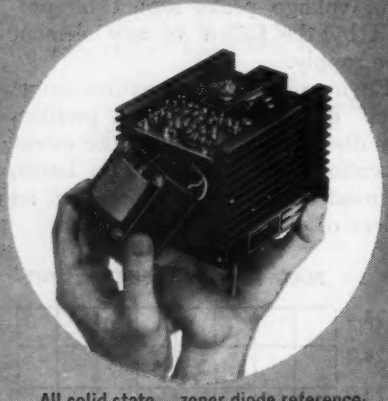
One piece finned aluminum extrusion, achieving high heat dissipation. Most units need no external heat sink to 55° C ambient. All units have adjustable output. Platform mounted standardized subassemblies and components enable quick delivery of a wide range of voltages and currents.

Specifications:

Input: 105 to 125V AC, 45 to 420 cps, single phase
Regulation: 0.1% (line or load)
Stability: Better than 0.25% for 8 hours
Ripple: 0.02% rms
Response time: less than 100 microseconds
Low dynamic impedance

Designed primarily as a component power supply, units are widely used in computors, electronic instrumentation, production test equipment, and quality control check out systems. Best of all, the unique design makes these units available at the lowest possible cost to you.

(Unit pictured above: Model #1R 90-.1; 85-95 V; 0-100 ma; Price $145.00) Prices on other units range from $100 to $200.



All solid state — zener diode reference; transistor amplifiers and regulator
Output Voltages: from 2.0 to 300V DC
Output Power to 30 Watts
Reliable short circuit protection
All components readily accessible

CONSOLIDATED AVIONICS CORPORATION
A SUBSIDIARY OF CONSOLIDATED DIESEL ELECTRIC CORPORATION
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CIRCLE NO. 40 ON INQUIRY CARD

COMPONENTS DIGEST

SUMMARY DATA CHART

The foregoing discussion is meant only to introduce the user to various types of supplies and their performance characteristics. To complete this Digest, a summary data chart on pages 50 and 51, lists most of the main performance criteria of typical supplies.

Since a tremendous number of units are produced, we chose only representative samples from each manufacturer and tried to weight the selection toward the most popular supplies. For this reason no very high voltage units are presented, although, as was mentioned in the discussion, many are available.

NEW DC POWER SUPPLIES

Solid State Modules

Model PS 202 with dual output up to 150 milliamps at ±18 volts or a single output at ± 36 volts is 8″ x 3″ x 3″, weighs two lbs, line and load regulation is ± 1% with less than six mv of ripple, and is a highly stable supply for use, primarily, where a reference source is required. Line regulation from 95 to 135 volts ac input is 0.1% with continuously variable dc output of two of 24 volts. Load regulation is 0.1% with loading of zero to 100 milliamps. Temperature stability is 50 parts per million per degree F in the range of 40 to 120 F. Module dimensions are 7.5″ x 3.5″ x 2.5″. Solidyne, La Jolla, Calif.

Write No. 343 in Box on Inquiry Card

Controlled Rectifier Supply

Model CR-36-6 is said to be the first well regulated dc supply incorporating a silicon controlled rectifier to be offered as a standard catalog unit. It is rated at 0 to 36 volts and 0 to 6 amps output. The unit's characteristics are similar to a series of transistorized supplies, called the QR series that are said to provide maximum power per cu. in. at 3½ in. panel height. Load regulation is ±0.01% and line regulation is ±0.03%. Output voltage remains within regulation for instantaneous, prolonged steps of line voltage of ±10%. Recovery time for no load to full load step change does not exceed 25 microsecs. NJE Corp., Kenilworth, N.J.

Write No. 493 in Box on Inquiry Card

Servo Supply

For use in small servo systems, unit contains a filtered, unregulated full wave bridge dc supply and two isolated outputs (one at four watts and one at 0.5 watts capacity). It complements transistorized servo amplifiers and supplies motor fixed phase power as well as excitation to a synchro or potentiometer. Unit can circumvent noise and severe transient voltages in 28 volt dc lines of aircraft, missiles, and other vehicles. Kearfott Div., General Precision, Inc., Little Falls, N.J.

Write No. 496 in Box on Inquiry Card

Dual Modular Units

Model RS-473 provides two outputs of positive 300-400 and negative 300-400 volts; or a single output of 600-800 volts. The ranges are available at currents up to 25 ma. Both supplies track each other throughout their ranges with single voltage adjustment control located at the top of the chassis. Unit is available as a bench module for laboratory use or as a flat-plate module for installation into original equipment. Line regulation is 0.02% and load regulation is 0.03%. Recovery time is less than 25 microseconds. Trans Electronics, Inc., Canoga Park, Calif.

Write No. 348 in Box on Inquiry Card

Airborne Supplies

Five watt dc power units for instrumentation, telemetering and recording systems are available with a nominal output of either five, ten or 15 volts. All models operate from standard airborne 115 volts, 400 cycle power. Dual magnetic power regulation consists of a flux oscillator and a magnetic amplifier regulator. The circuits suppress line voltage transients and are essentially unaffected by changes in load or by line frequency variations. Units meet applicable portions of Mil-E-5272A. Magnetic Rsrch Corp., Hawthorne, Calif.

Write No. 349 in Box on Inquiry Card

Four in One Supply

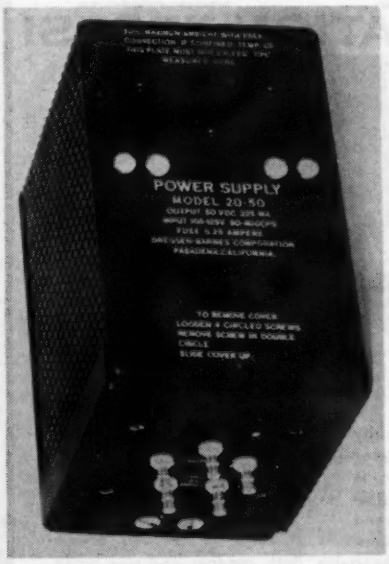
Unit contains four transistorized, regulated power supplies which are isolated and may be connected in many combinations for computers or transistorized equipment. Available voltages: One to 15 volts dc for each output in current ranges of 2, 4 and 8 amps with remote sensing and short circuit proof. Regulation is better than 0.1% for line and load. Ripple is better than 3 mv rms. Input range from 105 to 125 v, 50 to 400 cps, 1 phase. Size is 19" wide, 10½" high and 17¾" deep, adaptable for relay rack mounting. Operation up to 50C ambient. Anders Electric Products, Inc., Needham Heights, Mass.

Write No. 357 in Box on Inquiry Card

Dual Range Supply

Transistorized power supply, Model TP-36/18, contains a front panel switch for selecting either of two ranges of operation up to 2 amps at 0 to 18 volts in the first range and up to 1 amp at 0 to 36 volts in the second. In either range, line regulation is 10mv, load regulation is 5mv and ripple is 0.2mv rms. Two units can be mounted side by side in a 19-inch rack, 5¼ inches high, for operation as a dual supply; or, if operated in series, they provide either 0-36 volts at 2 amps or 0-72 volts at 1 amp. Invar Electronics Corp., Pasadena, Calif.

Write No. 359 in Box on Inquiry Card

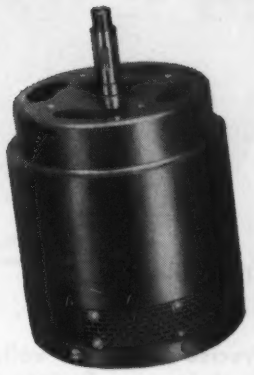


Externally Adjustable Supplies

24 models have an external potentiometer for output voltage adjustment, a removable external cover for easy inspection and maintenance, and either solder terminal or octal plug input and output connection. Output ranges from 5-50 vdc and 225 to 750 ma. Dressen-Barnes Corp., Pasadena, Calif.

Write No. 495 in Box on Inquiry Card

BASIC BUILDING BLOCKS FROM KEARFOTT



EXPLOSION-PROOF AXIALVANE BLOWER MOTOR

This thermally protected, explosion - proof induction motor drives an Axialvane blower unit used as an air circulator on aircraft air conditioning systems. Unit features high output to weight ratio in an extremely compact package and conforms with the requirements of MIL - M - 7969A. Motor has been environmentally tested to conform with MIL - E - 5272A per Procedure I, covering humidity, high and low temperature, explosion - proof, altitude and vibration requirements. These Model F-25-2 motors are produced by Kearfott's subsidiary, the *Hertner Electric Company.*

SPECIFICATIONS
Model F-25-2

H.P.	12.4
Volts	200
Phase	3
Cycles	400
RPM	11,600
Duty	Continuous
Dimensions	5½" diam. x 5 3/16" long
Weight	17.75 pounds

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

CIRCLE NO. 41 ON INQUIRY CARD

for

TRANSISTOR CIRCUITRY

a transistor-SAVING power supply

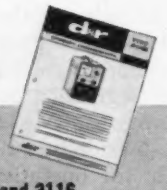
TYPE D-1480

6 to 30 volts D.C.
0 to 500 Ma.

Precise control of voltage and current. Put the D-1480 to work for you. Reduce costly transistor burn-outs.

Overloading cuts current off. Regulation better than 0.3%. Less than 0.25 mv. ripple. Full short circuit protection. Meter reads voltage and current.

Available from stock...factory or Allied Radio.
***(Allied Stock No. 82PX245)* .....price $160.00.**



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Rototest has installed a complete new facility utilizing the latest Ling equalizer-analyser system. With this new facility equalization is accomplished in narrow frequency bands. PSD Variations and spectrum shifts are analyzed while the test is in progress with constant monitoring to detect changes in test specimen behavior. Both random and sine wave excitations are readily super-imposed, and many different power spectral density curves readily shaped.

Capabilities:		
Force pound output	5,000	pds, (sine wave)
RMS force pound output	3,500	pds, (random)
Peak force pound output	10,500	pds, (random)

These are just a few of the advantages of this new facility.
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2803 Las Flores Blvd. Lynwood, Calif.

CIRCLE NO. 42 ON INQUIRY CARD

COMPONENTS DIGEST

Dual Supply

Two solid-state, convection-cooled power supplies containing military quality parts are sufficiently flexible to be used in the laboratory or for integration into a complex system. Model ZA-720 is a dual 12 volt, 5 amp power supply providing two completely independent 12 volt dc sources, rated at 5 amps each, isolated from ground and from the chassis. Load regulation is 0.1% for any load change between zero and five amps; ripple voltage is less than 0.001 volt rms under the worst combination for input voltage and output current. Front panel contains voltage and current meters as well as switching for monitoring the two power supplies independently. Model ZA-721 is a transistorized, 12 volt dc, one amp regulated power supply that plugs into a standard 14 pin miniature tube socket (with pin 10 blocked for keyway orientation). Center tap provides 33 volts ac for auxiliary positive bias. Engineered Electronics Co., Santa Ana, Calif.

Write No. 344 in Box on Inquiry C rd

Low Voltage-High Current

With load currents of 0 - 5, 0 - 15 or 0 - 30, the voltage output of three transistor regulated power supplies is 0 - 36 volts. Line regulation is better than 0.025% or three mv (whichever is greater) for input variations from 105 - 125 volts, 50-60 cycle ac (400 cps is available upon request). Load regulation is better than 0.05% or five mv (whichever is greater) for load variations from zero to full load. Ripple and noise is less than 1.0 mv rms. Each model is designed to fit standard 19" racks. Power Sources: Burlington, Mass.

Write No. 346 in Box on Inquiry Card

Blower-less 50 C Units

Convection-cooled, transistorized power supplies are available in five and ten amp, 0-34 vdc output ranges. Three and a half in. high and 14-¾ in. deep, the five amp model weighs 55 lbs. Ten amp model is seven in. high and weighs 100 lbs. Both models are standard 19 in. rack mounting. Despite a space savings design and elimination of blowers, the units are rated for continuous performance at full load up to 50 C. Line and load regulation exceed 0.15% or 20 mv for input variations of 100-130 vac and from zero to full load. Lambda Electronics Corp., College Point, N.Y.

Write No. 345 in Box on Inquiry Card

KEARFOTT produces

precision floated gyros

for the Polaris missile.

***Engineers:** Kearfott offers challenging opportunities in advanced component and system development*

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KEARFOTT DIVISION
Little Falls, New Jersey

GP

GENERAL PRECISION, INC.
Other Divisions: GPL, Librascope, Link

CIRCLE NO. 140 ON INQUIRY CARD

SUMMARY OF PERFORMANCE CHARACTERISTICS

OF DC REGULATED POWER SUPPLIES

Co. name (see buyer's guide)	ACDC	Acme	Allegany			Amer	Amp			Anders	Bosch
1. Model No.	RPM50-150	PS-6757	PS31783	710-C	705A	170	PS7486	PS7194	PS7348	TR230	1804-1300
2. Output v (vdc)	125-175	0-45	1-30	5-25	255	2	28	150	200	1-30	28
3. Output current	0-0.050	0-2.5	0-2	0-0.350	0.220	0-0.100	0-0.800	0.3-1.25	0.055-0.080	0-2	1.5
4. Regulation (%) Line Load 10% line changes no load to full load	0.05 0.05	2.5	0.1	0.05	1	0.01 5.0	1	0.1	0.5	0.1	5
5. Ripple (mv rms max.)	1	450	1	1.75	18	0.5	1	70	70	1	-----
6. Response time (msec)	0.025	-----	0.05	-----	-----	1*	1*	75*	40*	0.05	-----
7. Max. amb. temp. (°C)	50	40	50	54	-----	-----	70	85	71	50	71
8. Overload protection	No	Yes	Yes	Yes	No	-----	Yes	Yes	Yes	Yes	-----
9. Input frequency (cps)	50-60-400	60	50-100	60	60	50-60	57-63	380-420	380-420	50-400	400
10. Size and weight (cu. in., lbs.)	182, 9	997,-	1397,35	302,8.5	1945,57	1947,22	211,9	480,14	53,2.6	957,-	54,2.5
11. Type of unit (**)	VM	VR	TR	-----	R	TR	TM	VM	TAM	TR	TM
12. Remarks						*63% re	*37.7% output recovery after step change in line v and/or load curr. Mil components				

Co. name	Electronic Measurements			Elec S	Eng E	Engineered Magnetics		Flite	Harrison			Invar
1. Model No.	TO14-30	2601AK	220A	PS-126	Za721	EM-4-150	EM542	PCR-275	200D	808A	855	TP-15
2. Output v (vdc)	0-14	0-300	0-50	5	12	150	28	250	150-315	0-36	0-18	0-32
3. Output current (amps)	0-30	0-0.100	0-0.500	0.25	1	0.05	0.110	0.160	0-0.8	0-5	0-1.5	15
4. Regulation (%) Line Load 10% line changes no load to full load	0.03	0.01	0.1	0.1	0.1	0.5	0.1	0.1	0.003 0.002	0.01 0.03	0.03	0.03 0.01
5. Ripple (mv rms max)	1	1	1	5	1	4.2	1	10	1.5	1	0.5	0.4
6. Response time (msec)	0.1*	0.2*	1*	-----	-----	-----	-----	100	-----	0.1*	0.075*	0.05*
7. Max amb. temp. °C.	45	-----	45	74	65	124	124	-----	50	50	50	50
8. Overload protection	Yes	Yes	Yes	No	-----	Yes	Yes	Yes	-----	Yes	Yes	Yes
9. Input frequency (cps)	50-60	50-60	50-60	400	-----	380-420	380-420	-----	50-60	50-65	50-440	50-65
10. Size and weight (cu.in., lbs.)	4788,137	1207,33	1247,30	9,-	38.9,-	34,3	115,6.25	72,3	642,30	1596,45	324,11	1995,72
11. Type of unit (**)	TR	VB	VR	M	TM	TM	TM	AM	VM	TR	TB	TR
12. Remarks	*Recovery to regulation from no load to full load				Mil comp.	Mil specs	Mil specs	Mil specs		*output recov to within reg of mean of no and full loads		*no load to full load

Co. name	Mide	Moel	NJE		Neff		Netw	North	Perkin	
1. Model No.	ME100-1	21	QR-18-6	TRM28-30	2-302	2-200	102-31-0	-----	M-1188	MTR036-5
2. Output v (vdc)	0-100	0-20	0-18	24-32	5-15	0-15	28	60	27.5,28.5	0-36
3. Output current (amps)	0-1	0-1	0-6	0-30	3	5	0.25	0-10	5	5
4. Regulation (%) Line Load 10% line changes no load to full load	0.1	0.05	0.03 0.01	0.1	0.1	0.01	1	0.6	1	0.04 0.06
5. Ripple (mv rms max)	1	0.1	1	0.003	0.7	0.7	2.8	0.18	285	2
6. Response time (msec)	0.05*	-----	0.025	15	-----	-----	10	25*	0.1*	0.1*
7. Max. amb. temp. °C.	50	50	45	35 --	85	54	85	50	50	45
8. Overload protection	Yes	Yes	Yes	Yes	Yes	Var.	Yes	Yes	Yes	Yes
9. Input frequency (cps)	60	50-60	60-400	60-400	360-440	50-60	400	48-62	60	60
10. Size and weight (cu.in., lbs.)	1566,-	931,15	1105,41	5893,160	216,9	1828,70	11,7	3325,150	605,35	1596,30
11. Type of unit (**)	TR	TR	TR	T-AR	TM	TR	M	TR	AM	A-TR
12. Remarks	*for half current step changes				Mil specs		Mil specs	*with 50% load change	*for recov to 65%. Mil specs	*for recov to 65%

(**) A - Magnetic amplifier regulated
B - Bench Model
M - Modular unit
R - Standard rack model
T - Transistor regulated
T-A - Transistor magamp regulated
V - Vacuum tube regulated
A-T - Mag. Amp. -Transistor regulated

BUYER'S GUIDE

The above tabulation is only representative of the range of units available from manufacturers; contact manufacturer for additional information on special units prior to final selection.

ACDC Electronics, Inc., 2979 North Ontario St., Burbank, Calif.
Acme Electric Corp., Cuba, N. Y.
Allegany Instrument Co., 1091 Wills Mt., Cumberland, Md.
American Electronic Labs, Inc., 121 N. Seventh St., Phila., Pa.
Amp, Inc., Capitron Div., 155 Park St., Elizabethtown, Pa.
Anders Electric Products, Inc., Brooks Rd., Needham Hts. Mass.
Arnoux Corp., 11924 W. Washington Blvd., L. A., Calif.
M. Ten Bosch, Inc., 80 Wheeler Ave., Pleasantville, N. Y.
Computer Control Co., 983 Concord St., Framingham, Mass.
Consolidated Avionics Corp., 800 Shames Dr., Westbury L.I., N. Y.
Daven Co., Route 10, Livingston, N. J.
Del Electronics Corp., 521 Homestead Ave., Mt. Vernon, N. Y.
Deltron, Inc., 4th and Cambria Sts., Phila., Pa.
Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.
Elasco, Inc., 5 Prescott St., Roxbury, Mass.
Elcor, Inc., 1225 West Broad St., Falls Church, Va.
Electronic Measurements Co., Inc., Eatontown, N. J.
Electro Products Labs., 4500 Ravenswood Ave., Chicago, Ill.
Electronic Specialty Co., 5121 San Fernando Rd., L. A., Calif.
Engineered Electronics Co., 1441 E Chestnut Ave., Santa Ana Calif.

SUMMARY OF PERFORMANCE CHARACTERISTICS OF DC REGULATED POWER SUPPLIES

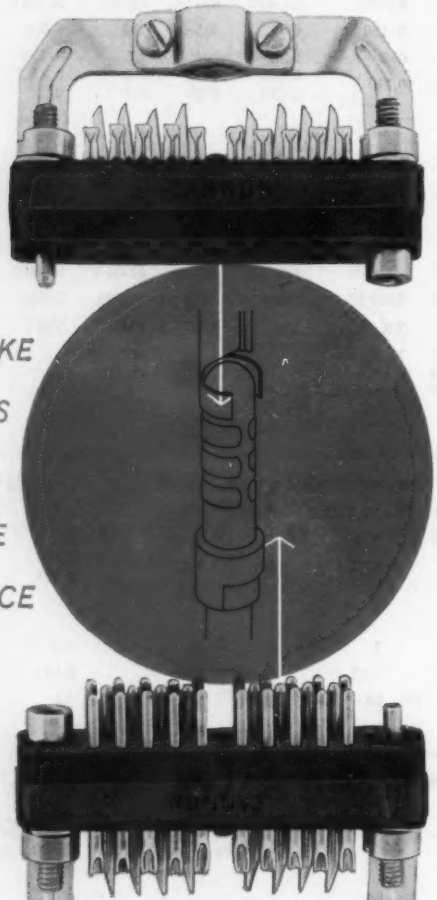
Co. name	Cons		Daven		Del	Delt	Dressen-Barnes					Elasco		Elcor
1.	IR15-1	Z	60AR50	61AR100	SCRT	H1503	62-103	62-140	22-121	22-111	22-101	M6-50	V28-500	-----
2.	10-20	0-50	50	100	10-32	0-150	0-6	0.5-32	150	5-7	28	6	25-30	5-50
3.	1	2-15	0.290	0.170	0-15	0-3	0-1.00	0-2	2.5	0-3	0-5	0.05	0.5	0.04-0.15
4.	0.1	0.01	1 5	1 5	0.05 0.25	0.25	0.035 0.033	0.05 0.05	0.2 0.1	0.35 0.21	0.9 1.8	0.1	0.5	0.1
5.	5	0.5	15	15	1	3	1.5	1	2	2	15*	5	30	1
6.	0.1*	0.05*	-----	-----	0.1*	0.05*	-----	-----	-----	-----	-----	0.1	0.1	200
7.	55	50	150	150	25	40	-----	-----	-----	50	-----	50	50	50
8.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9.	45-420	48-62	-----	60-1600	55-65	-----	60	60-400	60-400	60-400	60	60-400	60-400	50-400
10.	98,6.5	2261,80	29.8,1.7	29.8,1.7	1296,65	2327,50	2358,56	1109,34	343,22	228,9	259,20	40,1	57,2.5	26.9,1
11.	TM	TR	TM	TM	TR	TR	VR	TR	VM	TM	AM	TM	TM	VM
12.	*for 10% line or 50% load trans.	*37.7% recov. after step change in line	Mil Specs		*for 100 mv trans. spike	*for max load or line transients			Mil comp.		*with filter			

	Invar	Julie	Kaiser		Kepco				Krohn	Lambda			Mide
1.	102	PVS-105A	KAO6/.2-60	ARL15-3	SM14-30	PSC-20-2	KR 16	KM236-15A	UHR-220	LT 1095M	C-280M	26	ST18-6
2.	100	50	6	0-15	0-14	17.5-22.5	0-150	0.1-36	0-500	0-32	0-200	100-200	0-18
3.	1	0-0.100	0.200	3.0	0-30	0-2	1.5	0-15	0-0.2	0-1	0-0.200	0-0.100	0-6
4.	0.1	0.005	0.25 0.5	0.01 0.03	0.1	0.02	0.1	0.5	0.003 0.001	0.15	0.15 0.25	1	0.005 0.05
5.	7	0.7	5	1	1	1	3	40	0.1	1	3	5	0.5
6.	0.05*	0.1	-----	0.5	0.05	0.05	0.05	200*	0.001	0.05*	-----	-----	0.05*
7.	60	-----	50	50	50	50	50	50	50	50	50	40	55
8.	Yes	-----	Yes	yes	Yes	Yes	-----	Yes	Yes	Yes	Yes	Yes	Yes
9.	50-65	60	60-400	50-60	60	50-65	50-65	57-63	50-60	50-400	50-400	50-400	60
10.	420,17	3724,80	54,-	803,-	2306,-	337,-	3956,-	3956,-	1125,54	956,35	1434,53	672,19	1496,-
11.	TM	R	TM	TR	TR	TM	VR	AR	VR	TR	VR	VB	TR
12.	*no load to full load		Mil specs					*output within 0.5% during recovery		*for step func. load changes	*for step func. load changes		*for half current step change

	Phil	Power D	Power Sources		Quan	Sorensen			Statham	Stelma	Trans		Valor	
1.	R100B*	105TA	PTR22A	PS4305	124	Q6-2	QM6.3-.32	MA12-60	PS4-0	PS-10B*	RS110	RM 205	PS108M	PS130
2.	300	1-100	10-20	0-36	0.1-50	4.5-8	6.3	9-18	9-11	15	0-110	150-225	1.5-32	5-20
3.	0.100	0.5	0-0.2	0-5	0-2	0-2	0.32	0-60	0-0.150	2.5-8	0-0.100	0-50	0-3	0-0.2
4.	0.01 0.0007	0.05	0.25 0.2	0.025 0.05	0.01	0.25	0.05	0.1 0.2	0.1 0.2	1	0.1	0.1	0.1	0.05
5.	0.5	1	7	1	0.5	1.5	1	180	1	150	2.1	4.9	2	1
6.	0.015	0.05	-----	0.1*	0.05	0.05	0.05	150	-----	-----	-----	-----	0.1	0.1
7.	65	50	60	50	40	40	-----	-----	50	50	-----	-----	50	60
8.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-----	Yes	-----	Yes	Yes	Yes
9.	50-70	55-440	50-60	50-60	50-60	50-60	60-400	60	50-400	50-60	55-400	60	60-400	46-64
10.	498,15	578,18	34,2.5	1567,40	1496,43	237,7.25	55,-	5070,127	40,-	2510,63	229,7.5	568,-	997,15	98,5
11.	VR	TR	TM	TR	TR	TR	TM	A-TR	M	R	VM	VR	TR	TM
12.	*dual pwr unit		Mil specs	*for step inc. no load to full						*dual pwr unit				

(**) A - Magnetic amplifier regulated
B - Bench model
M - Modular unit
R - Standard rack model
T - Transistor regulated
A-T - Mag. Amp.-Transistor regulated
V - Vacuum tube regulated
T-A - Transistor magamp regulated

Engineered Magnetics, Div. Gulton Ind., 13041 Cerise Ave. Hawthorne Cal.
Flite-Tronics, Inc., 3312 Barton Ave., Burbank, Calif.
Freed Transformer Co., Inc., 1718 Weirfield St. Brooklyn, N. Y.
Harrison Labs, Inc., 45 Industrial Rd., Berkeley Hts., N. J.
Hays Corp., 742 E 8th St., Michigan City, Ind.
Invar Electronics Corp., 323 W. Washington Blvd. Pasadena Calif.
Julie Research Labs, Inc., 556 W 168th St., N. Y., N. Y.
Kaiser Electronics, Inc., 3 Monroe St., Union, N. J.
Kepco, Inc., 131-38 Sanford Ave., Flushing, N. Y.
Krohn-Hite Corp., 580 Mass. Ave., Cambridge, Mass.
Lambda Electronics Corp., 11-11 131 St., College Pt., N. Y.
Magnetic Research Corp., 3160 W El Segundo Blvd. Hawthorne Cal.
Mid-Eastern Electronics, 32 Commerce St., Springfield, N. J.
Moeller Instrument Co., Richmond Hill, N. Y.
Neff Instrument Corp., 2211 E Foothill Blvd. Pasadena, Calif.
Networks Electronics Corp., 14806 Oxnard St., Van Nuys, Calif.
NJE Corp., 20 Boright Ave., Kenilworth, N. J.
North Electric Co., Galicon, Ohio
Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.
G. A. Philbrick Rsrches, Inc., 127 Clarendon St., Boston, Mass.
Power Sources, Inc., Burlington, Mass.
Power Designs, Inc., 1700 Shames Dr., Westbury, L.I., N. Y.
Quan-Tech Labs, Route 202, Boonton, N. J.
Solidyne, 7460 Girard Ave., La Jolla, Calif.
Sorensen and Co., Richards Ave., South Norwalk, Conn.
Statham Instr., Inc., 12401 W Olympic Blvd., L. A., Calif.
Stelma, Inc., 200 Henry St., Stamford, Conn.
Trans Electronics, Inc., 7349 Canoga Ave., Canoga Park, Calif.
Valor Instruments, Inc., 132-14 Crenshaw Blvd. Gardena, Calif.



NEW CLAW-LIKE OPERATION GIVES POSITIVE ELECTRICAL CONTACT IN THE SMALLEST SPACE

CANNON/TUCHEL

MICRO-MINIATURE PLUGS

These amazing micro-miniature plugs incorporate a completely new operating principle! Electrical contact is made by pushing the pin into a claw-like socket constructed of several springs of diminishing diameter. And check these design extras! Greater mechanical grip of interlocking parts ■ automatic cleaning of contacts ■ lower electrical resistance ■ positive electrical contact even in the smallest space. For use in aircraft and portable instrumentation, or for any miniature electronic equipment...ask for Cannon/Tuchel Plugs—another reason why you should consult the world's most experienced plug manufacturer....why you should consult Cannon for all your plug requirements. Write for literature to:

CANNON PLUGS

CANNON ELECTRIC COMPANY 3208 Humboldt St., Los Angeles 31, Calif.

CIRCLE NO. 44 ON INQUIRY CARD

COMPONENTS DIGEST

NEW DC POWER SUPPLIES (Cont.)

Transistor-Magamp Regulated

Designed especially for electrolytic capacitor forming and aging, CS-58TRM72B is rated at two to 300 volts dc at 0.6 to 30 amps. Transistor-driven magnetic amplifier circuitry contributes to a high degree of reliability and versatility. Pre-selected current is maintained during the initial charging interval to within ±2%. Voltage rises in proportion to the increasing load impedance until it reaches the pre-selected level and is then maintained within ± 0.5%. Ripple will not exceed 0.2 volts rms. NJE Corp., Kenilworth, N.J.

Write No. 350 in Box on Inquiry Card

For Transistor Circuits

Transistor regulated power supply, Model PS-3, provides, according to the manufacturer, top performance at one-half the cost of equipment now available. Unit is said to provide most of the voltages and currents, as well as filtering, required for work with transistors. Filtering circuits keep ac ripple below one mv rms for all conditions for rated operation and less than five mv for ac line voltage between 115 and 120 volts. Voltage remains essentially constant at any output voltage setting regardless of load (within ratings), and of ac supply voltage fluctuations. Heavy overloads or shorts cannot damage the unit. Output voltage ranges from 0-15 volts at 0-200ma or 0-25 volts at 0-100ma. Regulation is 500mv max. Electro Products Labs, Inc., Chicago, Ill.

Write No. 353 in Box on Inquiry Card

10 V-32 V at 0-15 A

Designed to supply well regulated dc at high current, solid-state supply has an output of 10-32 v dc at 0 to 15A (both sides floating with respect to ground). Silicon controlled rectifiers provide the basic regulation for line and load while transistors provide the transient suppression and dynamic filtering. Dynamic response is less than 100 mv transient spike for 100 microseconds for ± 2% amp step change in load current and less than + one v transient spike for 0.1 msec for step load change from 15A to 0 amps. Ripple is less than 1 mv rms. Del Electronics Corp., Mount Vernon, N.Y.

Write No. 355 in Box on Inquiry Card

Airborne Modules

Solid state power supplies primarily for airborne applications, are designed for precision regulation against line and load variation under wide ambient temperature changes and other severe environmental conditions. Arnoux Corp., Los Angeles, Calif.

Write No. 356 in Box on Inquiry Card

High Regulation

Model UHR-211 with an output range of 130 to 500 volts has current capabilities of zero to 1,000 milliamps at any voltage setting and at any line voltage over the operating range. Regulation is less than 0.004% plus 0.004 volt; ripple is less than 0.2 millivolt rms. Krohn-Hite Corp., Cambridge, Mass.

Write No. 360 in Box on Inquiry Card

For Missile Ground Support

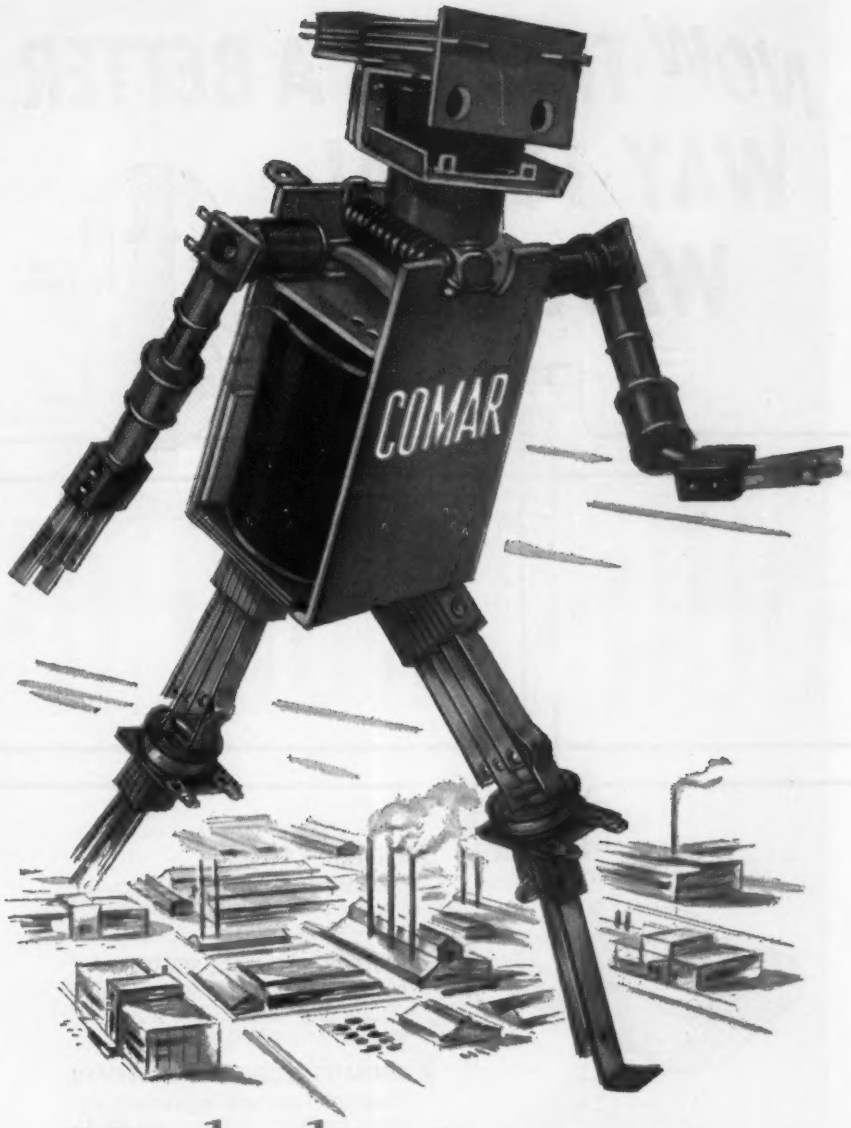
Two power supplies with magnetic amplifier regulation contain silicon rectifiers for resistance to high temperatures. M-1560 is constructed with baseplate mounting for inclusion into almost any module or rack mount. Output is 28 v at a continuous duty rating of seven and one half amps. Regulation is ± 1% for combined variations of line and load; ripple is 5% rms max. Unit meets Mil-E-4970. M-1348 is a ruggedized, weatherproof supply with an output of 24-32v at 100 amps. Regulation is ± 0.5% line and load combined and ripple is ½% rms based on an ac input of 208, 230, or 460v ±5% (reconnectable), 3 phase, 60 cps. Unit is provided with remote sensing and meets various Mil specs. Perkin Engineering Corp., El Segundo, Calif.

Write No. 352 in Box on Inquiry Card

Magnetic-Regulated

Regulated supply contains a reactor and a hermetically sealed constant voltage transformer. Unit is said to be competitive in price with power supplies using tubes. To allow for warmup, a time delay relay is adjustable from 30 seconds to 3 minutes. Input is 95 to 130 volts ac at 60 cycles; output is 155 volts dc at 150 milliamps, regulated to ±1% and ripple is less than 10 mv. A built-in 6.3 volt ac, 60 cycle supply is regulated to 1% against line variations of 95 to 130 volts. Freed Transformer Co., Inc., Brooklyn, N.Y.

Write No. 358 in Box on Inquiry Card



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● Producing relays fast and at low cost is a Comar specialty. Our complete engineering and manufacturing facilities are geared to save you time and money. Whatever type relay you need, simple or complex, industrial or military, Comar can serve you best. Write: Comar Electric Company, 3349 Addison Street, Chicago 18, Illinois.

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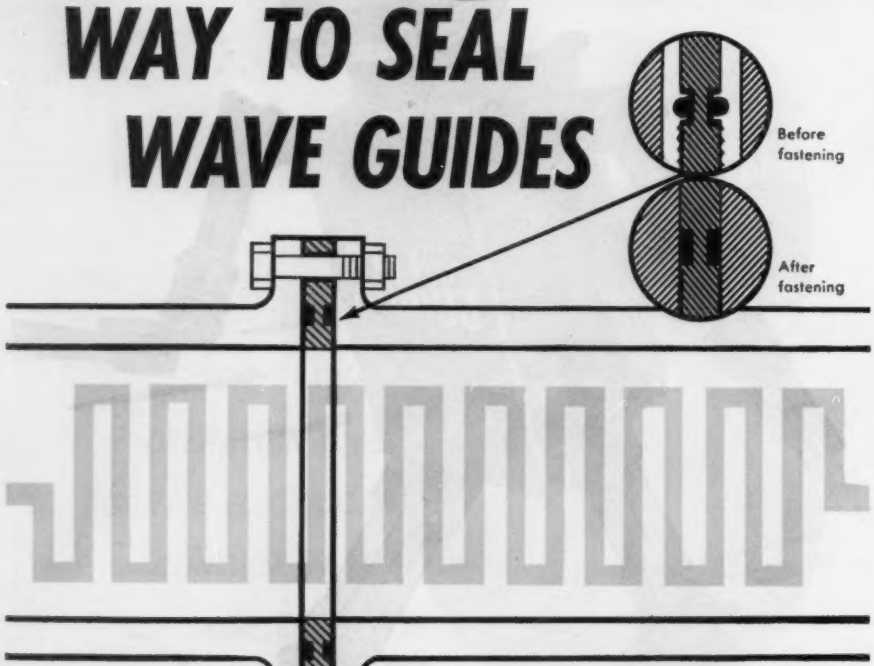
NOW THERE IS A BETTER WAY TO SEAL WAVE GUIDES



✓ **PREVENTS R/F LEAKAGE**
Metal-to-metal contact with "engraved fingers" on inside surfaces assures electrical continuity.

✓ **PROVIDES NO-LEAKAGE SEALING**
Controlled confinement of seal gland assures safe, sure, positive sealing — **exceeds** top hermetic specs!

✓ **ELMINATES ARCING AND/OR BURNING**
Designed to exacting requirements for proper mating of flanges as specified.

✓ **CAN BE RE-USED**
Seal is never "squeezed" beyond elastic limits, "memory" is constant, before, during and after fastening.

✓ **ECONOMICAL**
Eliminates cleaning or resurfacing flanges, no intricate machining required to accommodate the seal, and they're resuseable with just normal care.

✓ **STANDARDS FOR W/R SERIES**
Electr-O-Seals are available as standards to WR series Wave Guide flanges, assuring adequate supply and economy.

In addition to the standard WR series wave guide flange seals, Parker Seal Company also makes special seals to meet almost any specification or configuration. A nation wide group of field engineers are available to aid in expediting your requirements.

For more complete information send for catalog 5801.

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

CIRCLE NO. 46 ON INQUIRY CARD

COMPONENTS DIGEST

Three-way Overload Protection

Twin power supply PS202MB is said to be the first transistorized unit available with complete three-way overload protection provided by instantaneous electronic lock-out plus variable current limiting, primary fusing and load fusing. Variable current limiting prevents unit from delivering in excess of any preset power level. Damage due to short circuits is eliminated by the instantaneous electronic shut-off which automatically resets after shorts are removed. Specs are: two outputs, each 6-30 vdc at 0.5 amps; transient response, 35 mv for 50 usec or less; line regulation, ±1mv, load regulation, 50mv for 0-0.5 amp load change; ripple 300 μv rms; size, 7"x7"x8"; input 105-125, 60-400 cps. Valor Instr., Inc., Gardena, Calif.

Write No. 351 in Box on Inquiry Card

Portable Supply

Model MP-40-2, miniature portable supply was designed for remote programming in automatic systems. Transistors in the load circuit are protected against damage by a continuously variable electronic current-limiting circuit. Specs include: output 0 to 40 v dc at 0 to 200 ma; load regulation 0.05% for 0 to full load changes; ripple less than 500 microvolts; programmable from a distant point at 500 ohms per volt; dimensions are 6 x 8 in. Mid-Eastern Electronics, Inc., Springfield, N.J.

Write No. 354 in Box on Inquiry Card

Computer Units

Completely transistorized eight amp power supply especially designed for computer applications can be rack mounted in T-PAC systems where high package density is desired. Unit measures five and one quarter in. high, by 19 in. wide, by 11-½ in. deep and weighs 38 lbs. It will power 320 LE-10 Logical Element T-PACs operating continuously at one megacycle or 640 operating at 50% duty cycle. The front panel, which carries both a voltmeter and ammeter with full-scale ranges of 25 volts and 10 amps respectively, can be removed for access to the barrier type terminal strips located behind it. A special circuit for the protection of the transistors clamps the output to less than 25 volts and blows a fuse within three msec of the malfunction. Computer Control Co., Framingham, Mass.

Write No. 347 in Box on Inquiry Card

TRANSISTORIZED AC TO DC ELASCO MINISOURCE® POWER SUPPLIES

FIXED AND SEMI-VARIABLE

TRANSISTORIZED
Higher current capabilities in a smaller lighter package . . . greatly improved efficiences and reliability . . . less heat per watt input . . . no filament power losses . . . reduced transformer and rectifier losses . . . no warmup time . . . longer life.

COMPLETE SERVICEABILITY
All components accessible for checking and replacement . . . potting has been eliminated and a printed circuit board incorporated for compact packaging.

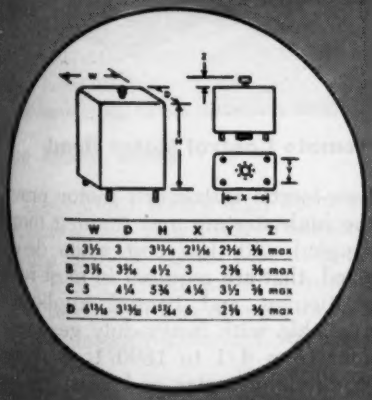
EFFICIENT HEAT TRANSFER
Accomplished by mounting the power transistor on the geometric center of the black anodized aluminum housing, which becomes an efficient black body radiating heat sink . . . Better heat transfer assures more accurate, stable and long-life performance of all components.

FULL PROTECTION
Fusing in the collector of the power transistor protects the supply without affecting regulation.

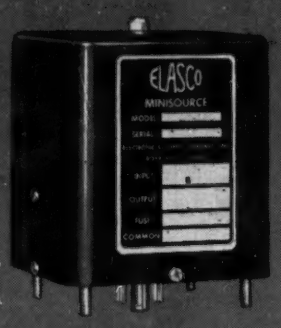
All standard Minisource® power supplies are furnished with an octal glass to metal header (other terminations available upon request) and packaged in a black anodized aluminum transformer case. There is no extra charge for 400 cycles.

SPECIFICATIONS
VOLTAGE REGULATED — FIXED OR SEMI-VARIABLE * OUTPUT

Input Frequency: 60 cps or 400 cps
Input Voltage: 105-125 VAC
Output Voltage: 4 to 200 VDC
Output Current: 50 to 500 ma
Regulation: Better than 0.5%
Ripple: Less than 0.25%
Polarity: May be used Floating, Positive, or Negative
*Screw driver adjustment on top of semi-variable units.



	W	D	H	X	Y	Z
A	3½	3	3¹¹⁄₁₆	2¹¹⁄₁₆	2½	⅜ max
B	3⅜	3¼	4½	3	2⅜	⅜ max
C	5	4¼	5¾	4¼	3½	⅜ max
D	6¹⁄₁₆	3¹⁄₁₆	4³⁄₁₆	6	2⅜	⅜ max



FIXED MINISOURCE

MODEL	VOLTAGE	CURRENT	CASE SIZE
M4.5-50	4.5v.	50 ma	B
M4.5-100	4.5v.	100 ma	B
M4.5-250	4.5v.	250 ma	B
M4.5-500	4.5v.	500 ma	B
M6-50	6v.	50 ma	A
M6-100	6v.	100 ma	A
M6-250	6v.	250 ma	A
M6-500	6v.	500 ma	B
M12-50	12v.	50 ma	A
M12-100	12v.	100 ma	A
M12-250	12v.	250 ma	B
M12-500	12v.	500 ma	B
M22-50	22v.	50 ma	A
M22-100	22v.	100 ma	B
M22-250	22v.	250 ma	B
M22-500	22v.	500 ma	B
M25-50	25v.	50 ma	B
M25-100	25v.	100 ma	B
M25-250	25v.	250 ma	B
M25-500	25v.	500 ma	B
M28-50	28v.	50 ma	B
M28-100	28v.	100 ma	B
M28-250	28v.	250 ma	B
M28-500	28v.	500 ma	B
M30-50	30v.	50 ma	B
M30-100	30v.	100 ma	B
M30-250	30v.	250 ma	B
M30-400	30v.	400 ma	B
M50-50	50v.	50 ma	B
M50-100	50v.	100 ma	B
M50-250	50v.	250 ma	C
M100-100	100v.	100 ma	C
M150-100	150v.	100 ma	C
M200-100	200v.	100 ma	C

SEMI-VARIABLE MINISOURCE

MODEL	VOLTAGE	CURRENT	CASE SIZE
V4-50	3-6v.	50 ma	B
V4-100	3-6v.	100 ma	B
V4-250	3-6v.	250 ma	B
V4-500	3-6v.	500 ma	B
V8-50	5-10v.	50 ma	A
V8-100	5-10v.	100 ma	A
V8-250	5-10v.	250 ma	B
V8-500	5-10v.	500 ma	B
V12-500	10-15v.	500 ma	B
V15-50	10-20v.	50 ma	A
V15-100	10-20v.	100 ma	B
V15-250	10-20v.	250 ma	B
V18-500	15-20v.	500 ma	B
V22-500	20-25v.	500 ma	B
V25-50	20-30v.	50 ma	A
V25-100	20-30v.	100 ma	B
V25-250	20-30v.	250 ma	B
V28-500	25-30v.	500 ma	B
V32-250	30-35v.	250 ma	B
V35-50	30-40v.	50 ma	B
V35-100	30-40v.	100 ma	B
V38-250	35-40v.	250 ma	B
V42-250	40-45v.	250 ma	C
V45-50	40-50v.	50 ma	B
V45-100	40-50v.	100 ma	B
V48-250	45-50v.	250 ma	C
V65-50	60-70v.	50 ma	B
V65-100	60-70v.	100 ma	B
V75-50	70-80v.	50 ma	B
V75-100	70-80v.	100 ma	B

ELASCO can package power supplies in any way the customer may desire (within reason) and to comply with military requirements.

ELASCO inc.

FIVE PRESCOTT STREET, ROXBURY 19, MASSACHUSETTS
Telephone: Highlands 2-1600

IF THE SUPPLY YOU REQUIRE IS NOT LISTED ABOVE, ELASCO WILL BE HAPPY TO BUILD A MINISOURCE® TO YOUR SPECIFICATIONS.

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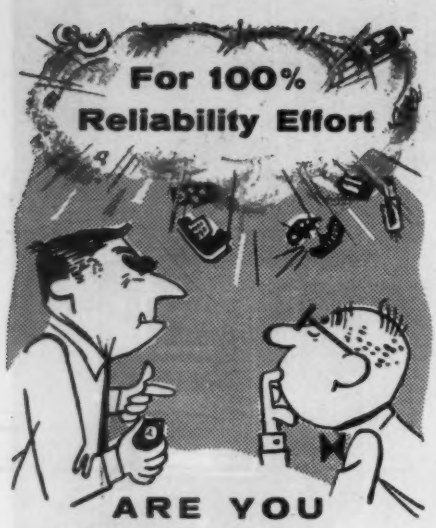
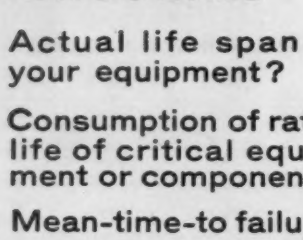


ARE YOU MEASURING . . .

- Actual life span of your equipment?
- Consumption of rated life of critical equipment or components?
- Mean-time-to failure?

You can reduce the odds against failure by constant monitoring and timely replacement of equipment approaching the end of assured performance . . . by thoughtful application of the . . .

WALTHAM
SUB-MINIATURE
ELAPSED TIME INDICATOR



MODEL WT-1 Actual Size

1 1/16" O.D. x 1 15/16" 3 OZ.
10,000 Hour Total Readout (Easily Read to Closest Hour) 400 CPS

Whether it's for reliability and life testing, design or system analysis, utilization studies . . . or to continuously monitor and log critical equipment or components . . . when you incorporate the Waltham WT-1 in your plans, you add that "measure of reliability" so important for military acceptance.

The WT-1 meets MIL-E-5272A and is available "FROM STOCK" Write Now for Bulletin 5001!

WALTHAM

PRECISION INSTRUMENT COMPANY
Waltham 54, Massachusetts
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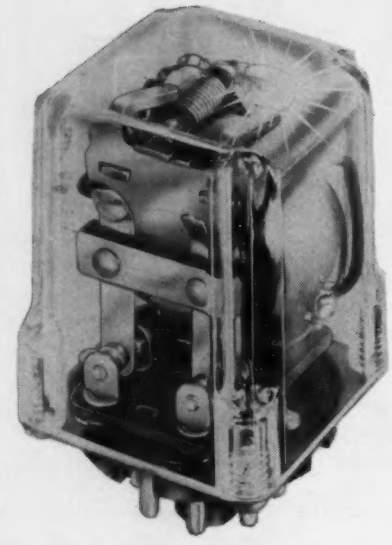
New Electromechanical Components For Electromechanical Systems



Relay with Indicator Lamp

Neon lamp built into a general relay is an aid to trouble shooting power circuits. The indicator is connected in series with a resistor and both components are connected in parallel to the relay coil to provide a positive means of determining current availability. A transparent cellulose acetate dust cover provides operating visability for lamp and contacts. Units are available for 6 to 110 volts dc or 6 to 230 volts ac operation. Silver cadmium contacts rated at 10 amps are standard for both ac and dc models. Potter & Brumfield, Princeton, Indiana.

Write No. 442 in Box on Inquiry Card

Control Recorders

Recorders are equipped with either one or two set points for maximum-minimum control of processes without duplication of instruments. There is no interference with writing pen since on-off contacts are inductively coupled to the transistorized control circuit by a vane attached to the pen arm. The "maximum set point" can be fixed in any position over a range of 30-100% of full scale and the "minimum set point" can be used between 0-70% of full scale. The two contacts can be adjusted for a minimum separation of ¾" (about 7% of full scale on standard size recorders). Accuracy of control varies between 0.5% at the center of the scale and 3.0% at the end of the scale. Curtiss-Wright Corp., Princeton Div., Princeton, N.J.

Write No. 463 in Box on Inquiry Card

Miniature Delay Relays

Hermetically sealed in metal cans, thermal relays with 9 pin-in socket provide delays of 2 to 180 seconds with a voltage range of 6.3 to 115 volts ac or dc (heater). Units are designed for both military and industrial uses. Thermal Controls, Inc., North Arlington, N.J.

Write No. 328 in Box on Inquiry Card

Disc Thermistors

Packaged in diode cans, disc thermistors of high-power handling capacity can be quickly and ruggedly secured to chassis and surfaces with a minimum of design mounting problems. The units can be mounted near transistors to compensate for thermal limitations thereby extending the useful range of transistor circuitry. The mount can also be electrically and thermally insulated from the mounting surface and provides easy mechanical attachment for other applications. Resistance ranges from 5 to 11,000 ohms. Fenwal Elec., Inc., Framingham, Mass.

Write No. 455 in Box on Inquiry Card

Remote Control Motor Head

Low-inertia instrument motor provides the high starting and running torques, coupled with low cost when de-energized, that are required in most remote positioning and control applications. Available with heavy-duty gear reductions from 4/1 to 1800/1, total space required by motor and gear case, less output shaft, is only 4¾ x 4¾ x 4¾ in. Typical performance ratings are 750 oz-in. minimum starting torque and 35 oz-in. running torque at 6 rpm and 50 percent intermittent duty. National Pneumatic Co., Inc., Boston 19, Mass.

Write No. 363 in Box on Inquiry Card

Printed Circuit Relay

Designed specially for use on printed circuit boards, a micro-miniature ac relay occupies 20% less space (0.8" X 1.09") of printed-circuit-board area. The installed height above the board is approximately 0.44". Terminals and mounting tabs conform with the popular 0.2" grid pattern. The relay operates at low coil power levels yet easily switches load currents of 2 amps resistive and higher, at 26.5 vdc or 115 vac. Standard units meet mil specs. Price Electric Corp., Frederick, Md.

Write No. 304 in Box on Inquiry Card

Tungsten Thermocouple

Especially recommended for use at 2000 to 2800 C., refractory metal thermocouples consist of tungsten versus tungsten 26% rhenium. Units can be used in vacuum, hydrogen or inert gases such as nitrogen, argon and helium. The high output of the device also makes it useful at lower temperature ranges. The combination of high melting point with low vapor pressures makes it useful in vacuums at both high and intermediate temperatures. The thermocouple, however, should not be used under oxidizing conditions or in the presence of hydrocarbon vapors as they will attack tungsten at temperatures above 1000 C. Englehard Industries, Inc., Newark, N. J.

Write No. 329 in Box on Inquiry Card

Miniature Plugs

Insulation material used in miniature plugs is white polyester which withstands temperatures up to 356 F. The plug design is based on the principle that keeping surfaces clean from oxidization is a more important factor than contact pressure. The female contact is constructed of "springy" parts which rub against the male contact, in operation, the male pin contact is gripped by the female contact as if by a pair of pliers. Units are available in 10–50 contact layouts. Cannon Electric Company, Los Angeles, Calif.

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Time Delay Relay

For applications where high current is required, a time delay relay consists of a transistor delay circuit operating two DPDT relays. Delay range is from 10 to 250 seconds. Units operate on 18 to 32 volts dc with a control voltage of 28 volts dc.

Having an overall accuracy of 2%, the 8 cubic inch relay withstands shocks of 100 ±5g, and vibrations of 10g from 5 to 2,000 cps. Ambient temperature range is from −65 to +125 F. The Sloan Co., Sun Valley, Calif.

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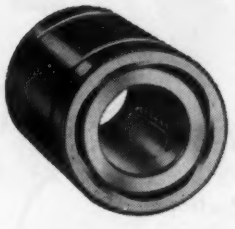
...*for* **MINIATURIZATION**



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New Electronic Components For Electromechanical Systems

Zener Diodes

Temperature-stable silicon zener diodes provide a resistance range from .10 to 60 ohms for units of low voltage types and from 3.6 to 60 ohms for medium voltage types. Operating temperature range is from −65 to +175 C. Maximum power rating is 250mw with a power derating above 50C of 1.5 mw degree C. Hughes Aircraft Co., Newport Beach, Cal.

Write No. 401 in Box on Inquiry Card

Cathode Ray Tube

High-frequency cathode-ray tube combines pattern control with high deflection sensitivity. For maximum brightness, all screens have highly-reflective metal backings. Spiral resistance windings allow a gradual voltage gradient. Unit is a 5¾-inch diameter tube, single beam, with electrostatic focus and deflection. Tight tolerances and conductive coating provide minimum pattern distortion. Allen B. Du Mont Laboratories, Inc., Clifton, N.J., U.S.A.

Write No. 445 in Box on Inquiry Card

DC to DC Power Supply

Transistorized power supplies convert low-voltage dc to higher-voltage dc. They are well regulated for variations of input line voltage as well as load power. Unit is regulated against both line and load variations simultaneously. Line input voltage variations of 30-24 volts dc (as might occur from a discharging battery) are reduced to 1% in the output; load variations from 10% to full load are similarly attenuated. Transient "spikes" in the line, or momentary overloads of ten to one of its rated power, will not damage the unit. Switching action is self-starting from −55 C to 74 C under all combinations of load and input voltage. Hermetically sealed and fully potted, the units have a life expectancy of high-quality transformers. Arnold Magnetics Corp., L.A., Calif.

Write No. 519 in Box on Inquiry Card

Solid Tantalum Capacitors

Solid electrolyte of hermetically-sealed capacitors insure a dry assembly with freedom from electrolyte leakage. Units meet all the requirements of Mil-C-26655A and operate over the temperature range of −80 to +125 C in dc voltage ratings of 6, 10, 15, 20 and 35 for +85 C and 4, 7, 10, 13 and 23 for +125 C operation. Aerovox Corp., New Bedford, Mass.

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Traveling-Wave Amplifier

Low noise traveling-wave amplifier covers the 2-4 kmc band with spot noise figures in the order of 2.7 db and fixed voltage noise figures below 4.8 db across the band. Tube is compatible in size, weight and power supply requirements with present solenoid-focused low noise tubes. Long life is anticipated because of the low cathode operating temperatures (typical 650 C) and high tube vacuum. Watkins-Johnson Co., Palo Alto, Calif.

Write No. 451 in Box on Inquiry Card

Banana Plug Resistors

Available in eight standard sizes from ¼ to two watt power dissipation, banana plug resistors' general specifications are: non-inductively wire wound; one to 0.005% tolerances; up to 0.001% stability; hermetic seal in epoxy resin; applicable sections of Mil-R93B and Mil-R94444. Consolidated Resistance Co. of America, Yonkers, N.Y.

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METALS
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GOLD doped with N-type or P-type elements—supplied in form of wire, sheet or ribbon and cut or stamped pieces.
INDIUM electroplated base or precious metal wires.
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- short circuit proof
- super-regulated
- overload protected
- low output impedance
- lowest ripple
- High-speed regulation
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MODEL T036-5M

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WIDE RANGE MODELS

MODEL NUMBER	D-C OUTPUT	
	VOLTS	AMPS
T060-15	0-60	0-15
T036-30	0-35	0-30
T032-30	0-32	0-30
T014-30	0-14	0-30
T07-30	0-7	0-30

Brief Specifications (all models)

REGULATION, LINE OR LOAD: 0.03% or 0.01 V (0.01% or 0.003 V available).

RIPPLE: Less than 1 millivolt rms.

CIRCUIT PROTECTION: (1) electronic circuit breaker plus (2) electromagnetic circuit breaker plus (3) input line fused.

NARROW RANGE MODELS ALSO AVAILABLE

REQUEST BULLETIN 721A (Revised) FOR COMPLETE SPECIFICATIONS

- sensing terminations
- front panel calibration
- any grounding arrangement
- small size, light weight

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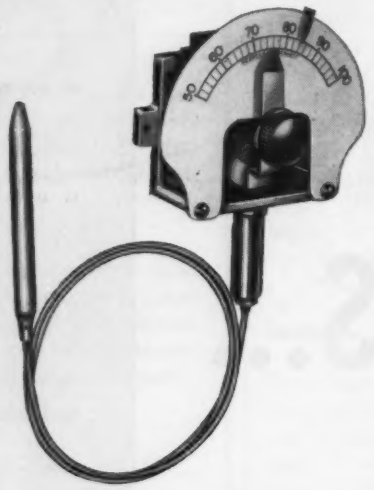
CIRCLE NO. 54 ON INQUIRY CARD

NEW INDICATING TEMPERATURE CONTROL

Range Limits —100 to +600°F E65N



New Design gives maximum accuracy at low cost!

The UE Type E65N control is offered in basic skeleton form so that it may be easily incorporated, or designed into equipment, without the need and expense of an enclosure. Enclosures, however, are available upon specification. Setting and indication are clearly visible on a single scale allowing easy reference between the setting and controlling temperatures. Ideal for incubators, centrifuges, oxygen tents, sterilizers, and other applications where it is necessary to control and indicate temperature of gases, liquids and hot plates.

Temperature Ranges	A wide variety of scales between −100 & +600°F.
Thermal Assemblies	Standard 4′ capillary with several bulb styles and sizes.
Operation	Liquid filled bellows assembly expands or contracts with heating or cooling thus actuating a snap-acting electrical switch at desired control point.
Switch Ratings	15 amps 115/230 volts AC. DC and other special switches available.
Switch Actions	Normally closed; normally open; and double throw, no neutral position.
Electrical Connections	Lead wires attached to terminal on switch.
Size & Weight	1 lb; scale plate 4½" wide.
Variations	Design variations available on request.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. For application requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Request Type E65N Design Catalog Sheet for complete specification and pricing data and for information regarding other United Electric temperature controls.*

United Electric Controls COMPANY

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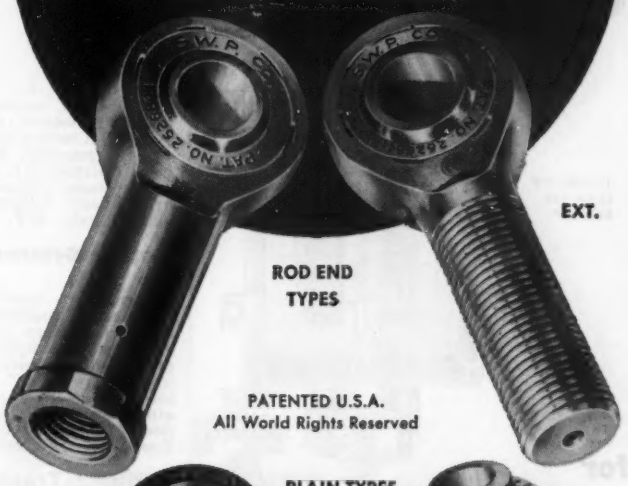

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No more pulling individual leads through conduit. And, "Thermo-cable", with its polyvinyl chloride weatherproof, heat and corrosion resisting outer sheath often eliminates the need for conduit. Direct burial types available to eliminate hazards from fire and mechanical damage.

T.E. weatherproof Terminal Boxes are made of cast iron or sheet steel, can accommodate from 6 to 100 circuits, and offer sure protection against the effects of contaminating atmospheres. Made to N.E.M.A. or JIC specifications.

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CIRCLE NO. 57 ON INQUIRY CARD

For Your 3-Ring Binder

NEW DATA SHEETS

For your free copy of the data sheets listed on this page, enter the appropriate number of the item on the Inquiry Card.

Relays 392

Descriptions, application and installation details, dimensions, ratings and ordering information on relays for all applications, including general purpose, machine tool, mechanically held (latched-in), pneumatic time-delay and synchronous motor-driven timing, are listed in 12-page bulletin. General Electric Co., Schenectady, N.Y.

Rotary Solenoid 391

Designed to meet military, industrial and commercial specifications, "D" size, 112 inch-lb-degree rotary solenoid comes in packaged adaptations complete with mechanical attachments and/or switching elements. "Engineering Data Sheet" on these units includes information on performance, size, voltage requirements, duty cycles and contains engineering and torque charts. Pacsol Div., Illinois Tool Works, Hawthorne, Cal.

Variable Transformers 390

Variable transformers for low voltage applications such as transistorized power supplies, plating-bath power supplies, etc. have input voltages of 36 volts or less; output currents of 5, 12, and 22 amperes depending upon the model. Complete details listed in bulletin. Ohmite Mfg. Co., Skokie, Ill.

Voltmeter 389

Expanded scale voltmeter achieves secondary standard accuracy over a wide frequency range with stability and ruggedness required for production usage. The instrument has impedance of 1000 ohms/volt with accuracies of 1/10 of 1 percent AC, 1/20 of 1 percent DC in panel meters. Voltron Prods., Pasadena, Cal.

Motor-Tach Generator 388

Size 8 precision hi temp motor tach generator of corrosion resistance materials meets military environmental specs. Bulletin on unit contains tables giving electrical, mechanical and physical characteristics, and shows outline drawing, schematic and torque curves. John Oster Mfg. Co., Avionic Div., Racine, Wisc.

Toggle Clamps 387

Miniaturized, vertical-handle and horizontal-handle toggle clamps with complete specifications are listed in bulletin which also includes tracing templates. Detroit Stamping Co., Detroit 3, Mich.

Time Delay Relay 386

Working in conjunction, a magnetic and electronic circuit provide accurate time delay periods to 15 seconds and greater under all environmental conditions after release of coil power. Operate and full recycle time is accomplished in less than 25 milliseconds. The unit has switching capacity to 3 PDT at 5 amps. E. V. Naybor Laboratories, Port Washington, N.Y.

DC Voltage Monitor 382

Miniature d-c voltage monitor has full-time precision sensing with Go/No-Go output. Bulletin describes its features, specifications and gives outline drawings. Trio Laboratories, Inc., Plainview, N.Y.

Log Converter 399

Four-page application note describes the use of a logarithmic converter as a computing element. When used in pairs and with a suitable read-out device the system performs multiplication and division. F. L. Moseley Co., Pasadena, Calif.

Multiple Transformer Winder 398

Catalog page illustrates and gives full technical details on 2 medium range multiple transformer winders: one winds 7 to 31 AWG; the other winds 10 to 31 AWG. George Stevens Mfg. Co., Chicago 46, Ill.

Adhesion in Teflon Wire 397

Simple dip process, requiring less than five minutes to complete, is a new development in adhesion promotion of Teflon insulated wires and cables to insure bondability with various potting compounds. A number of technical data charts are included in bulletin on this subject, showing increases in pull-out strength when the new techniques are employed. Hitemp Wires, Inc., Westbury, N.Y.

RFI Measuring Equipment 396

Complete description, applications and specifications of radio-interference-field intensity measuring equipment, covering the frequency range of 375 mc to 1000 mc, with a sensitivity of from 20 to 40 db greater than Mil-Specs require, are contained in 4-page bulletin. Stoddart Aircraft Radio Co., Inc., Hollywood 38, Cal.

Infrared Linear Heat Sources 395

Bulletin gives full information on pre-engineered modular oven components incorporating T-3 quartz lamps, quartz tubes or metal rods as sources for infrared heat. Fostoria Corp., Infrared Div., Fostoria, Ohio

Blocking Oscillators 394

Incorporating in their design RCA subminiature, high performance, low power "Nuvistor" vacuum tubes, monostable, astable and counting blocking oscillators are described in catalog listing complete data on the general, electrical, mechanical and environmental characteristics of each BO type, together with typical performance charts, photos of output pulses and the handy 6-unit kit designed for laboratory use. Mini-Rad, Inc., North Hollywood, Cal.

Push Button Switches 393

Single and double row assemblies of from 4 to 12 stations with interlocking action, illuminated or non-illuminated push button switches are described in bulletin which includes photographs, dimension drawings and detailed specifications. Donald P. Mosman, Inc., Brewster, N.Y.

Magnetic Modulators 378

Engineering specifications of magnetic modulators are listed in detail giving input and output voltages, pulse widths, efficiency, environmental information, temperature range, altitude, weight and physical dimensions on data sheet. Also included are illustrations of separate low and high voltage sections as well as combination unit. Voi-Shan Electronics, North Hollywood, Cal.

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